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- McCoubrey — Frequency Control by Microwave Atomic Resonance
- Brown — Ferrimagnetic Limiters
- Zorzy & Muehlberger — RF Leakage Characteristics of Popular Coaxial Cables and Connectors, 500 Mc to 7.5 Gc
- Ksienski — Signal Processing Antennas — Part II

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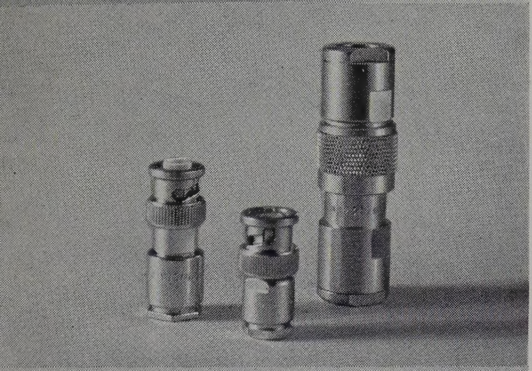

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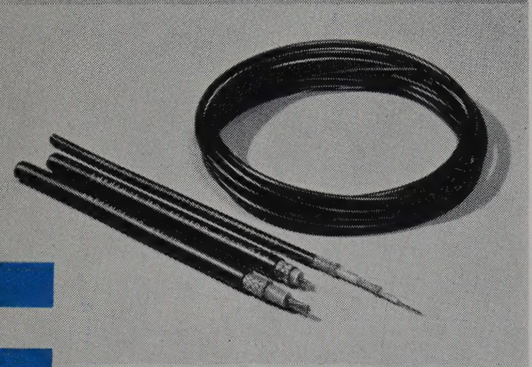

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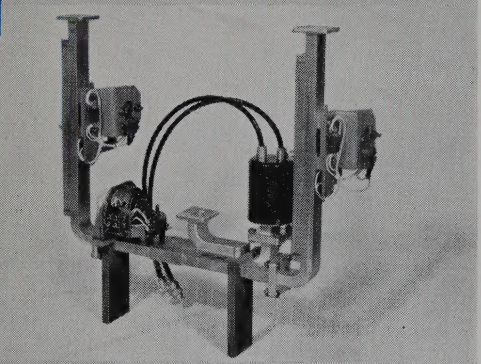

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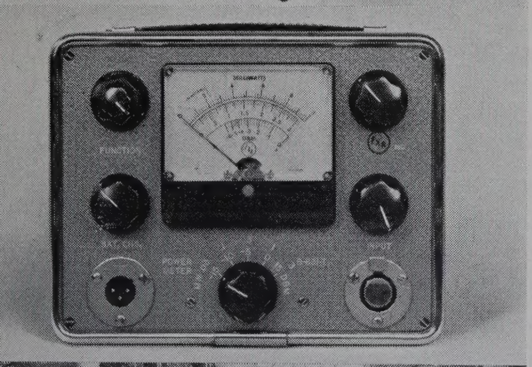

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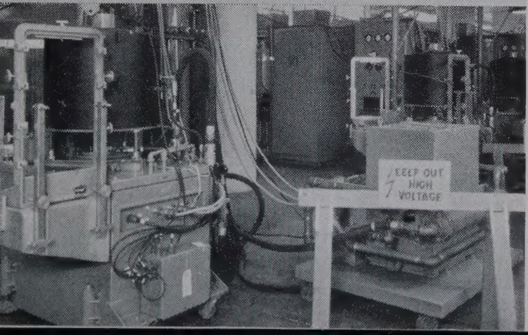

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NOVEMBER, '61 vol. 4 - no.11

the microwave journal

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A Very Broadband Microwave Antenna Coupler

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BPA

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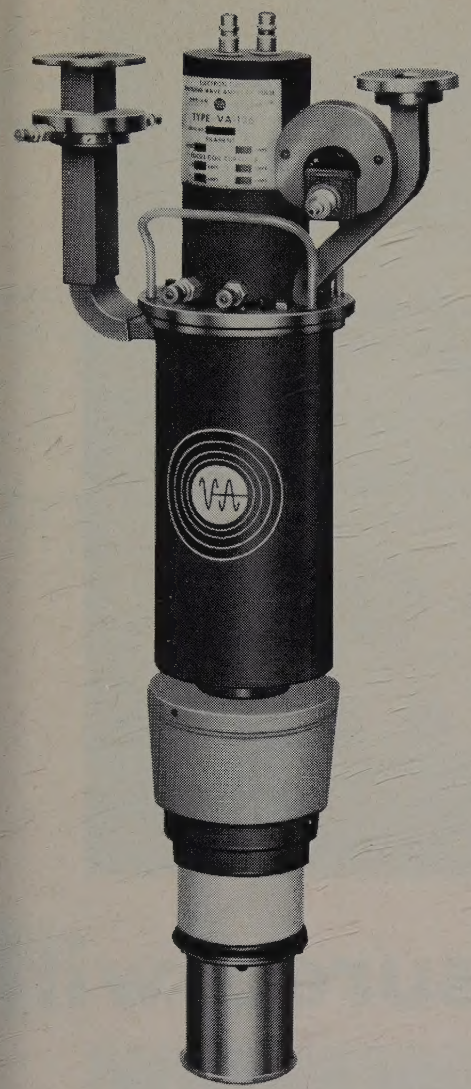
HIGHEST POWER TWT

3 MEGAWATTS AT C-BAND



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5.4 to 5.9 kMc

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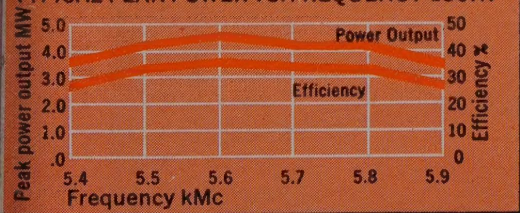
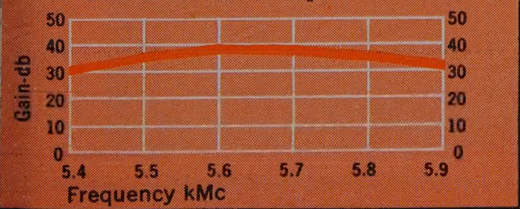
TYPICAL PEAK POWER VS. FREQUENCY-130KV



TYPICAL GAIN VS. FREQUENCY-130KV



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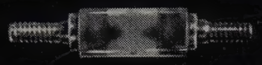

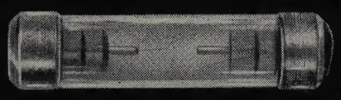

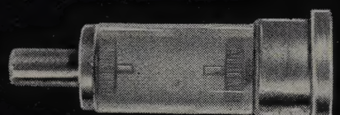

Model	Type	Element	Cartridge Type	Nominal Resistance @ Bias Current (25° C Amb)	Bias Current For Nominal Resistance (ma)	Price
38B1	821	Barretter	Fuse	200	8.75 ±0.25	$12
38B2*	823	Barretter	Fuse	200	8.75 ±0.25	$14
38B3	560	Barretter	Threaded	200	8.75 ±0.25	$15
38B4*	825	Barretter	Threaded	200	8.75 ±0.25	$14
38B6	Coax	Barretter	Disc	200	4.0-5.0	$25
38B7	—	Barretter	Crystal	200	8.75 ±0.25	$12
38B10	543	Thermistor	Threaded	100 135 200	12.8±1.0 10.2±1.0 7.5±1.0	$25
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33S2	2.60- 3.95	1.30	$150
33L1	.95- 1.22 (coax)	1.30	$100
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33G3	5.85- 8.20	1.30	$ 90
33C3	3.95- 5.85	1.30	$ 95
33S3	2.60- 3.95	1.30	$120
33B2	.50-11.00 (coax)	1.50	$ 75

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MICROVIEWS
OF THE MONTH

65 ▶ **FREQUENCY CONTROL BY MICROWAVE ATOMIC RESONANCE**

A. O. McCoubrey

Advances in microwave technology have stimulated the development of frequency standards based upon quantum mechanical resonances in atoms and molecules. These new devices have performance characteristics which go far beyond those which have been available from conventional devices in the past. The most intensive developments have recently been directed toward three techniques, which are discussed and compared in the present article. The detailed performance characteristics arising out of these methods are not the same, and an understanding of the differences is essential to their application in systems and engineering work.

74 ▶ **FERRIMAGNETIC LIMITERS**

J. Brown

The state of the art of ferrimagnetic limiters has now progressed to a point so that they can be substituted for gaseous TR tubes in microwave systems Limiters have been built which offer complete protection for crystal mixers or detectors, or for varactors in parametric amplifiers. The limiters are passive devices and have no fundamental lifetime limitations. Some theoretical principles are presented and their application to the design of ferrimagnetic limiters is discussed. Other design criteria are also presented in the paper and experimental results are shown.

80 ▶ **RF LEAKAGE CHARACTERISTICS OF POPULAR COAXIAL CABLES AND CONNECTORS, 500 MC TO 7.5 GC**

J. Zorzy and R. F. Muehlberger

(First of a series on Precision Connectors and Coaxial Devices)

The leakage characteristics, or shielding effectiveness of cables and connectors, are evaluated. This information will be useful to those concerned with bridge, slotted-line, and attenuation measurements, for example, where spurious signal paths produce significant errors. The leakage characteristics of types BNC and N, both conventional GR types 874-B and the new doubly shielded GR 874-BL Connectors, and of popular coaxial cables are given for the 500Mc to 7.5Gc frequency range.

(The second paper of this series will appear in the January issue)

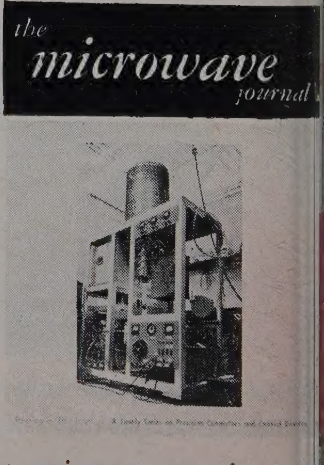
87 ▶ **SIGNAL PROCESSING ANTENNAS — PART II**

A. Ksienski

Various types of signal processing techniques are described and analyzed. The techniques described in this (second) part of the paper involve the use of a band of frequencies as the parameter by means of which improved antenna performance characteristics are achieved. The added frequencies may appear either as modulation frequencies which produce periodic changes in the aperture excitation or as wide band signals which are passed through matched filters to improve the effectiveness of an array regarding its size and element density. These techniques differ substantially from those described in the first part of the paper which applied to (essentially) monochromatic signals and derived their enhanced characteristics from nonlinearities or switching operations.

OUR COVER

Shown is an experimental atomic hydrogen maser microwave frequency standard which is operated under the supervision of Dr. R. F. C. Vessot at Bomac Laboratories. The research based upon this apparatus is directed toward the measurement of the very high degree of potential performance discussed in the article beginning on page 65 of this issue, and toward an understanding of the fundamental limitations.



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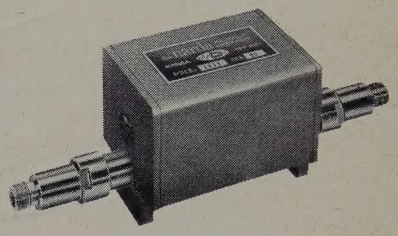
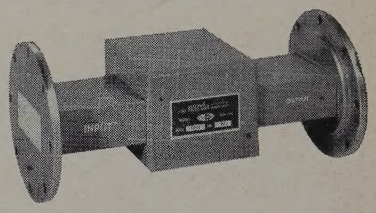


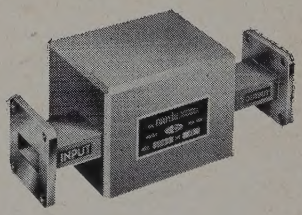
Excellent electrical characteristics with extreme versatility! ⅞″ coaxial line construction allows higher power operation with ⅞″ connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, ⅜″ connectors; 10 kw peak, 10 watts average.) Features 15 db isolation and 1 db max. insertion loss. VSWR is 1.25 max. based on 2:1 load mismatch; 1.15 max. into matched load. Model 1233: 2.0—4.0 kmc; model 1233-1: 3.0--5.5 kmc; $450. each.

• low power broadband waveguide ferrite isolators



Provide maximum load isolation and minimum insertion loss over full standard waveguide frequency ranges. Extremely useful for maintaining signal source stability and eliminating long line and frequency pulling effects. Front-to-back ratios are the highest available on the market today: C Band—26:1, $250; XN Band—25:1, $225; XB Band—30:1, $235; X Band—30:1, $220.

• high power broadband waveguide ferrite isolators



The only line of high power isolators that covers all of X Band with just two models (8.2-10.0 kmc and 10.0-12.4 kmc), each with front/back ratio of 40:1. Input power rating: 250 kw peak, 300 watts average, achieved through use of special high Curie temperature ferrite materials. VSWR is 1.05 max. with matched load; 1.10 max. with 3:1 mismatch. Only $175 each. Model with same VSWR, 28:1 front/back ratio, 300 kw peak, and 300 watts average, for 7.05-10.0 kmc, $195.

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From the editor-in-chief

THE FOUR QUALITIES

The engineering shortage has its compensations. Like taxes and the weather, it makes an interesting topic of conversation — or of editorials. It has enabled engineers to demand and get high salaries. But there is another point of view that deserves some consideration. What about the shortages in the engineers themselves?

Because of the engineering shortage, people seldom discuss this other point of view.

It is unfortunate, but true, that too many engineers lack a few of the basic qualities that help make the difference between an average engineer and the creative, aggressive, hard working type of engineer that is so badly needed in industry today. Where they acquire these qualities, I am not sure. Probably from their home environment, hopefully from school, and possibly from their supervisors. But their lack is an even more serious problem than the engineering shortage itself.

The qualities I am referring to in this instance are imagination, a sense of responsibility, patience, and the ability to look at the overall problem without overlooking the details. There are others to be sure, but these I feel are especially significant.

Imagination, the first of these, is probably the most important. It is the sort of thing that one does not develop easily. Consider this interesting definition of the word itself: mental synthesis of new ideas from elements experienced separately. Obviously, it involves the use of the mind. And I prefer to think of the mind as behaving somewhat like a muscle — unless you exercise it, it becomes flabby.

Next is the matter of responsibility. Here we find too many people, engineers included, anxious to avoid responsibility and yet ambitious for success. The two are not compatible. Success comes partly from the process of accepting and discharging responsibility. A sense of responsibility is a built-in safety margin to success.

The third quality is patience. Engineering is a profession that demands it. There are few breakthroughs that are not accompanied by hours of patient, continuous effort.

The ability to look at the overall picture without overlooking the details, the fourth quality, is in fact a measure of maturity. It is a quality that every good administrator, manager, and chief engineer must have. More often than not, it takes years to develop and only after much trial and error.

If it were possible to acquire these qualities by swallowing a pill, the so-called engineering shortage would be solved over night.

But who could stand the prosperity!

Ted Saad

ERE IS NO RELIABILITY LIKE DIODE SOLID-STATE RELIABILITY*

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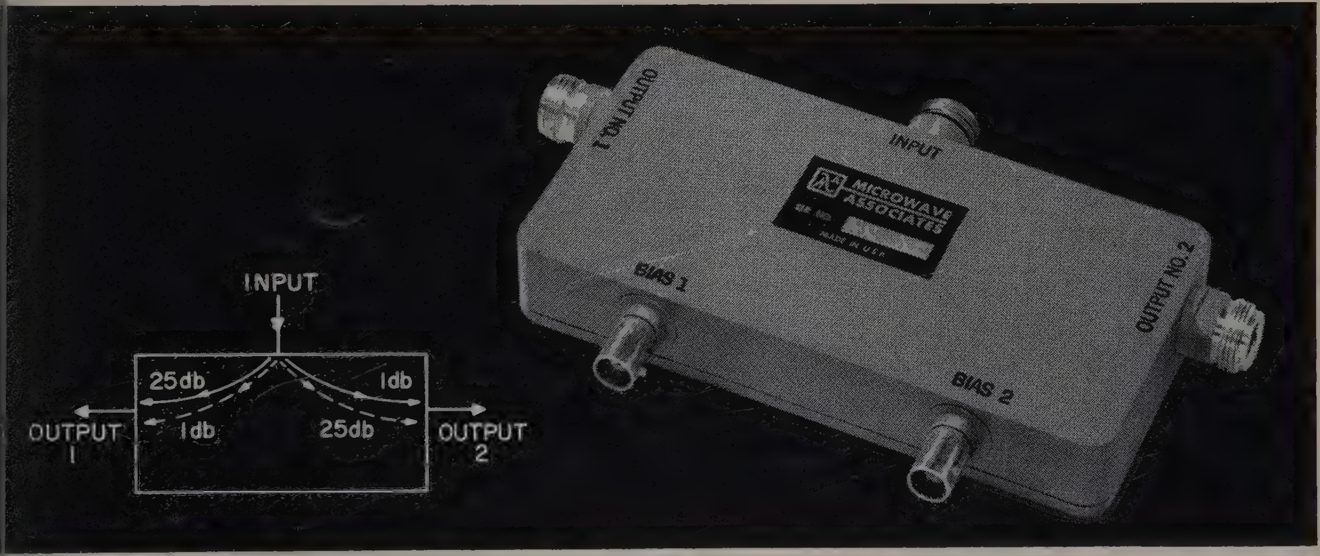

Microwave Associates has expanded its line of all-solid-te microwave devices with this new family of high wer switches.

For applications at frequencies through 7 kMc, these axial transmission line units provide ruggedness, light- ight (units typically less than 16 oz.), and long-lived iability which is not possible with other switching thods. The low drive power of these new units is un- tched. They provide 25 db isolation with 1 db insertion s at 10 kw peak power, .002 duty cycle, and with typi- bandwidths of 10%. Switches with higher power han- ng capability are currently under development.

For applications such as Antenna Lobing, Electronic anning of phased array antennas, High Power Modulation, and Variable Attenuation there is immediate advantage with these units.

* Since there is no magnetic field to change, these switches are inherently faster than ferrite switches. Operating temperature is from −55°C to +125°C.

Please contact Mr. Richard DiBona for specific details relating to your application.

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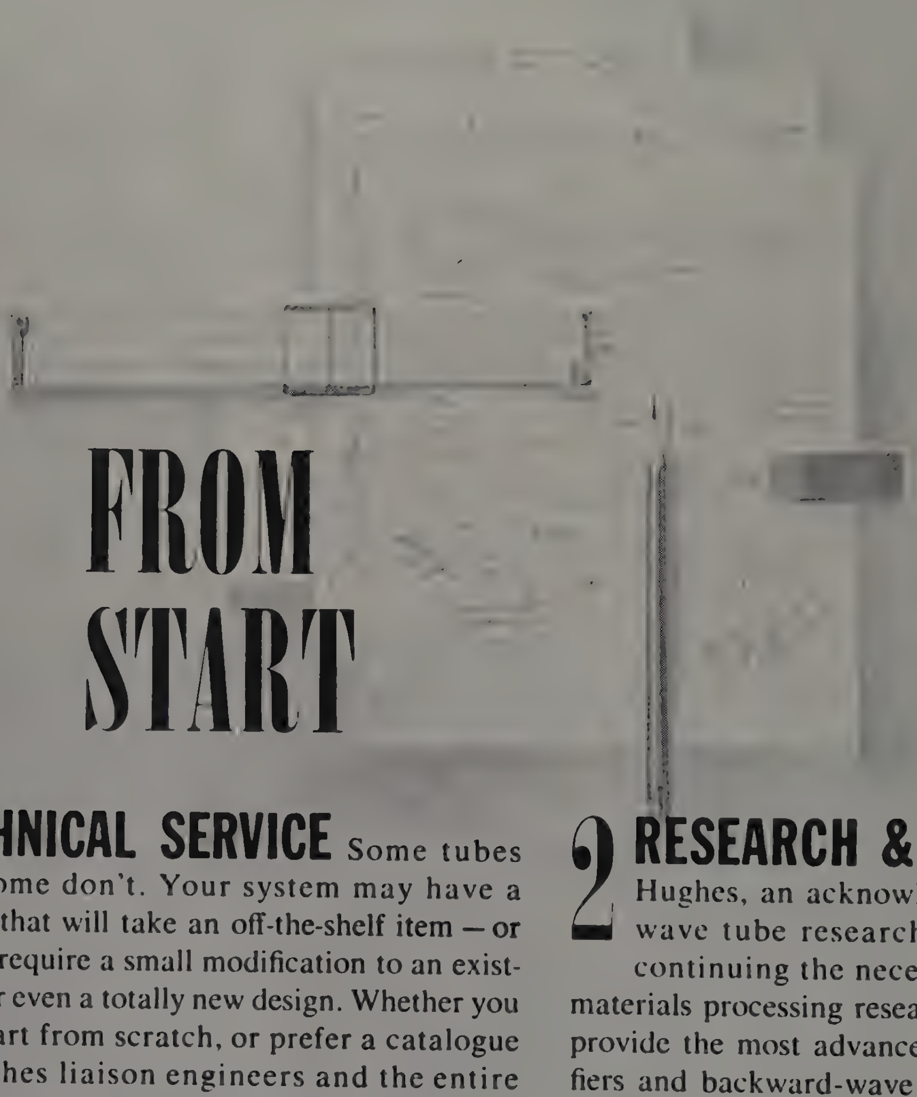

FROM START

1 TECHNICAL SERVICE Some tubes fit – some don't. Your system may have a socket that will take an off-the-shelf item – or it may require a small modification to an existing tube, or even a totally new design. Whether you want to start from scratch, or prefer a catalogue item, Hughes liaison engineers and the entire Division will provide just the service needed.

2 RESEARCH & DEVELOPMEN
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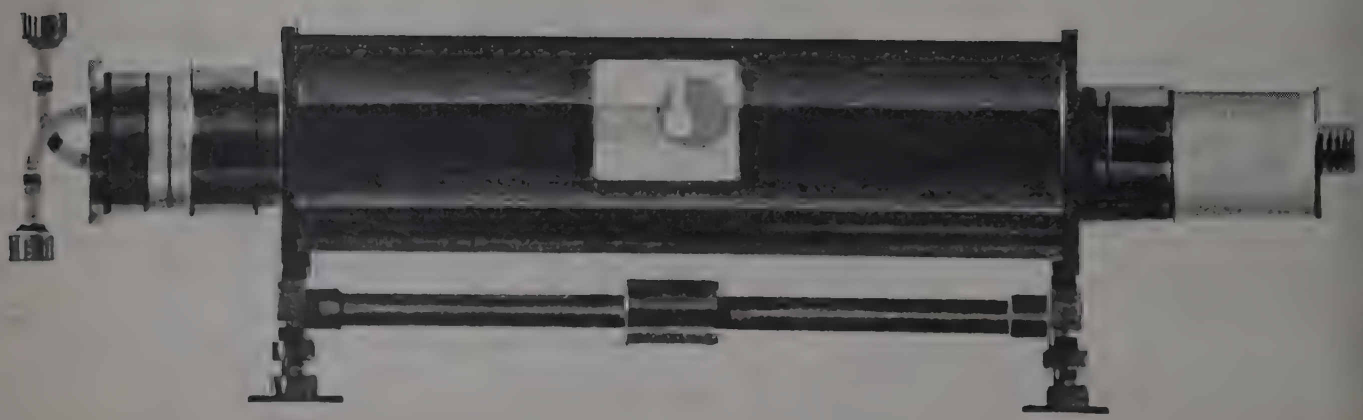
continuing the necessary gun, circuit, a
materials processing research and development
provide the most advanced traveling-wave am
fiers and backward-wave oscillators for the n
generation of ECM, radar, and communicati
systems. These advanced programs are suppor
by a variety of prime contractors and milit
agencies as well as company funds.



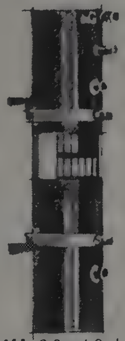
RAVELING WAVE TUBE PROBLEMS

TO

FINISH

PRODUCTION Hughes is now delivering traveling-wave tubes at annual rates that number in the thousands. This outstanding growth results from an ability to transform sophisticated development tubes into production versions rapidly and economically. It also includes the ability to deliver one off-the-shelf item or an entire communications or weapons system tube requirement, bering in the hundreds, with equal dispatch and reliability of product.

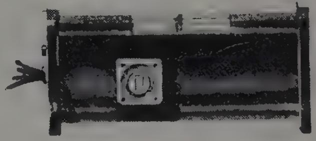
H 8.5—9.5 kMc; 50 Min P_o; 500 W Ave 54 db Gain; PPM used



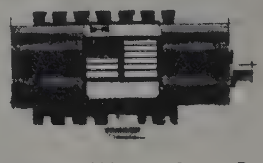
311H 2.0—4.0 kMc; 1 KW Min P_o; 10 W Ave P_o; 36 db Gain; Gridded, PPM Focused

310H 8.5—10.5 kMc; 1 KW Min P_o; 20 W Ave P_o; 40db Gain; PPM Focused

308H 8.6—9.8 kMc; 15 KW Min P_o; 150 W Ave P_o; 53 db Gain Gridded, PPM Focused



346H 7.0—12.4 kMc; 30 mw P_o; PM Focused BWO.



316H 12.4—18.0 kMc; 10—65 mw P_o; PM Focused BWO.

more information about the production TWT's shown above, her Hughes tubes, contact your nearest district office.

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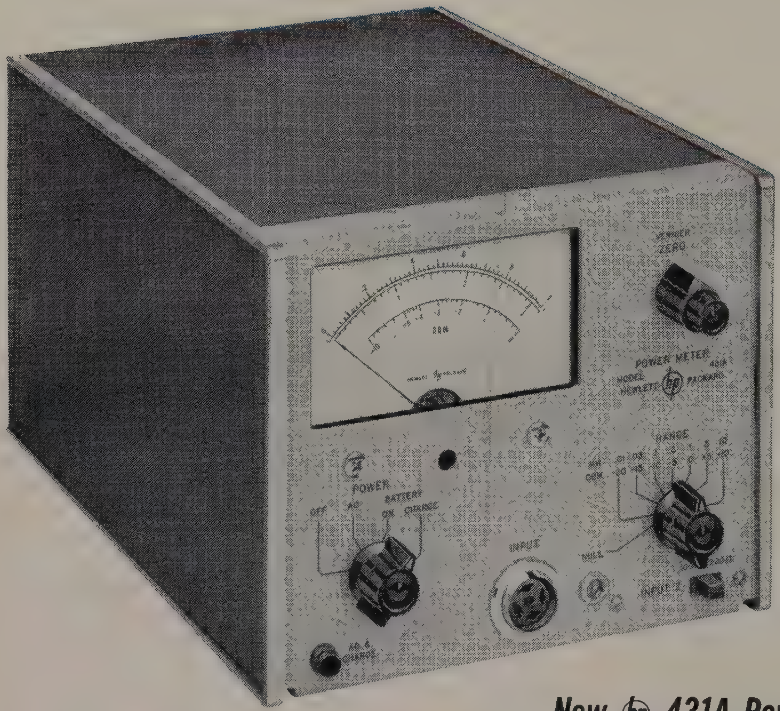

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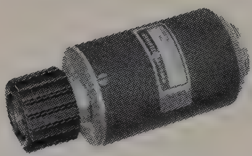
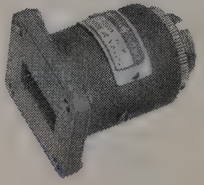


ⓗⓟ 478A Thermistor Mount

This wide-range, temperature compensated coaxial mount covers 10 MC to 10 GC, with no tuning required. Closely matched thermal environments for the two thermistor pairs for use with the dual bridge ⓗⓟ 431A assure excellent tracking, even under thermal shock. The ⓗⓟ 478A as used with the ⓗⓟ 431A provides high accuracy and virtually drift-free operation.

SPECIFICATIONS

Frequency Range:	10 MC to 10 GC
SWR:	Less than 1.5 (less than 1.3, 50 MC to 7 GC)
Power Range:	1μw to 10 mw (with ⓗⓟ 431A)
Elements:	Four 100-ohm, negative temperature coefficient thermistors permanently installed.
Price:	$145.00



ⓗⓟ 486A Waveguide Thermistor Mount

X-Band Mount, 8.2 to 12.4 GC, provides close
perature tracking with the ⓗⓟ 431A, even in the
ence of thermal shocks. No tuning is required
usual freedom from drift is assured with extr
close temperature tracking achieved through
ful matching of thermal environments for th
thermistors.

SPECIFICATIONS

Frequency Range:	8.2 to 12.4 GC
Power Range:	1μw to 10 mw
SWR:	Less than 1.5
Elements:	Two permanently installed 100-ohm negativ coefficient thermistors for each bridge
Waveguide Size:	1″ x 1½″
Price:	$145.00

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w hp Power Meter makes continual zero-setting a thing of the past, even on the 10 μw range, with temperature stability and a single zero-set covering all 7 ranges. You get a completely usable 10 tivity premium over previously available equipment.

ecially designed temperature compensated thermistor mounts are used with the hp 431A. The Coaxial Mount covers 10 MC to 10 GC, and the hp X486A Waveguide Mount covers X-Band.

balanced bridge technique and careful design and construction keep dc power in one bridge equal nknown rf power in the other. The dc power is then metered. High heat conductivity materials and l thermistors in close proximity in the 478A and 486A mounts provide extremely close thermal . Thus ambient temperature effects are automatically balanced out and the meter remains zeroed, the presence of thermal shock.

dvantages combine to make the hp 431A unusually useful for instantaneous microwave power ements. Microwave power standards measurements can be made to a high accuracy and resolu- using the dual bridge of the hp 431A as a transfer device. A dc calibration input jack permits precise ration of the thermistor mount. The grounded output jack will then drive an appropriate digital er for increased resolution. In addition, the grounded output jack, combined with the nearly drift ration of the 431A, makes reliable long term recordings of microwave power.

431A also has an optional rechargeable battery pack which will give up to 24 hours of completely e operation, as well as regular ac line operation while recharging.

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s:	7½" wide, 6½" high, 12½" deep. Weight 10 lbs.
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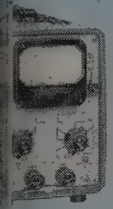
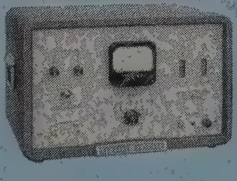


hp 430C Microwave Power Meter — 0.02 to 10 mw

This laboratory-proven meter gives instantaneous rf power readings direct in dbm or mw, 10 MC to 40 GC with hp proven bolometer mounts available now. hp 430C op- vith any bolometer operating at 100 or 200 ositive or negative temperature coefficient. djustable biasing current to 16 ma available ; bolometers to their operating range. Five anges are selected with a front-panel control, e readings of 0.1, 0.3, 1, 3 and 10 mw. Also ous readings —20 to +10 dbm. Accuracy is f full scale reading. Dimensions, (cabinet) 11½" x 14"; (rack mount) 19" x 7" x 13½" panel. Price, hp 430C $250.00 (cabinet); hp $255.00 (rack mount).



hp 434A Calorimetric Power Meter — 10 mw to 10 w

Here's the fastest, easiest means yet devised to measure powers accurately from 10 mw to *10 w*, dc to 12.4 GC! No barretter, thermistor, external terminations or plumbing are required. Measurements are as simple as connecting to a 50 ohm type N front panel terminal and reading directly. Only two front panel controls (range and zero); seven meter ranges for full scale readings of 0.01, 0.03, 0.1, 0.3, 1.0, 3.0 and 10 w. Also provides continuous readings —30 to +10 dbw. Accuracy ±5% of full scale (includes dc calibration and rf termination efficiency but not mismatch loss). Greater accuracy can be achieved through appropriate techniques. Dimensions, (cabinet) 20½" x 12½" x 14¾"; (rack mount) 19" x 10½" x 13½". Price, hp 434A, $1600.00 (cabinet); hp 434AR, $1,585.00 (rack mount).

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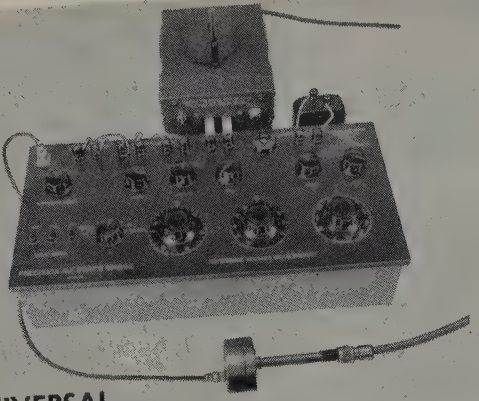

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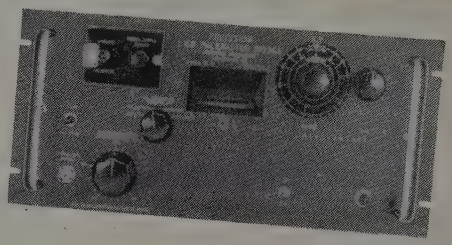
The Model PB-1 is a DC substitution bolometer bridge capable of accuracies to 0.1% in the measurement of substituted DC power. It is used in standards laboratories which require the highest attainable accuracy in high frequency power measurements. It is also used in the transfer of calibration factors from one bolometer mount to another. When used for very precise measurement of insertion loss up to about 10 db, this measurement becomes directly traceable to DC resistance and voltage standards.



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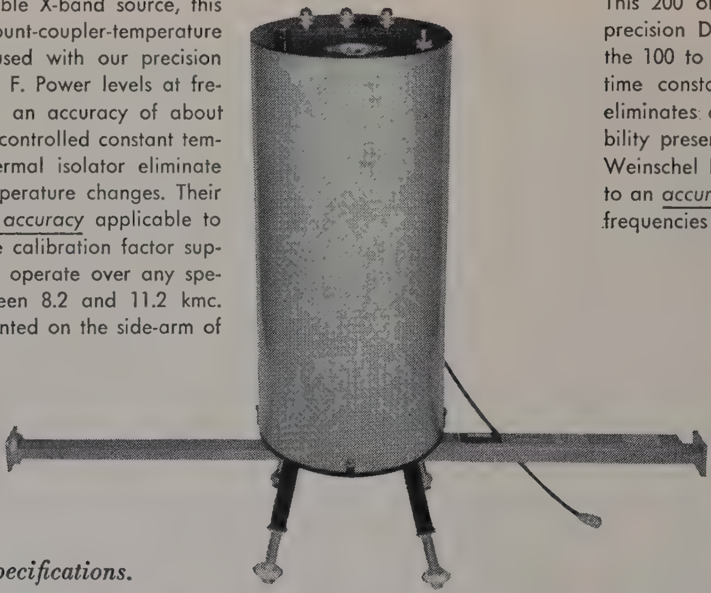

Model 675-A Coaxial Thermistor Mou

This 200 ohm thermistor mount is used with ou precision DC bridges to measure R. F. power, i the 100 to 4000 mc range. The very long therm time constant of the bolometer mount virtual eliminates ambient temperature changes. This sta bility preserves the calibration factor supplied b Weinschel Engineering at 400, 1000 and 1500 m to an accuracy of 2%. Calibration factors at othe frequencies are supplied on special order.

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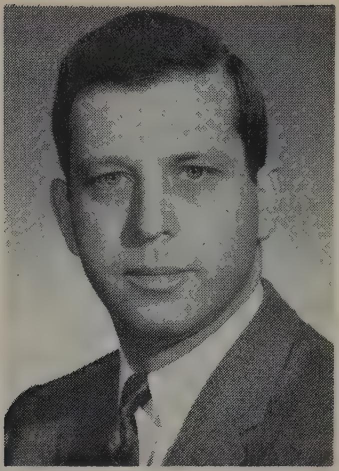

Bones from the Technical Graveyard

SEYMOUR B. COHN, ASSOCIATE EDITOR, *the microwave journal*

The technical literature performs an indispensible
vice, but often is a graveyard for good ideas.

Many an author's creation that deserves a better fate
buried in this graveyard, never to see the light of day
ess conceived again by someone else. Good ideas
not permanently die, of course, and may be rescued
m the graveyard and put to use by others who find
m. Many such prizes are the reward of those who
ve deeply into the dusty technical literature.

Burial and oblivion in the technical graveyard are
fortunately common rather than rare, and for many
sons. The new idea may have been presented in terms
easily understood by most readers. It may be lost in
body of the paper with inadequate guideposts in the
e, abstract, or introduction. It may have been pub-
hed before the technical community was ready to
preciate or use it, or it may be lost through an unfor-
nate choice of journal, reaching the wrong audience.

The exponential increase in technical papers is making
burial problem more acute. I cannot propose a
mplete solution, but can only suggest to an author
t he put all the effort he can into writing his paper
the audience that would best use the information,
her than writing it as an elegant monument to his
n ego. Great care should be taken in selecting the
oper audience, in presenting key ideas and facts in
rbal and mathematical language that the audience can
derstand, and in making clear the importance and
nificance of the essential information early in the
per before the reader's interest is lost. In my opinion
s the author who should bear the main responsibility
the one-way communication process, not the reader.

I will give three examples of little-known but useful
ts from the technical graveyard. The first is from my
n work. Buried deep in my nine-year-old paper
icrowave Coupling by Large Apertures"[1] is a prin-
le by which the cutoff frequency may be computed
r waveguide cross sections having parallel top and
ttom walls and various odd-shaped ends like those in
gure 1. This principle is simply that the cutoff fre-
ency of such cross sections is very nearly the same as
at of a rectangular cross section having the same
ight and same area. This relationship arises because
e side regions of the cross section contain an essential
iform density of magnetic energy, and negligible electric energy. Thus, if the shape of the side boundaries is varied while maintaining the area constant, the total energies will be unchanged, with the consequence that the guide wavelength, impedance and cutoff frequency will be unchanged. Figure 1 gives the approximate cutoff wavelengths for the cases shown.* As an illustration of the range of validity of this principle, comparison may be made between Figure 1a and a much

(*Continued on page 16*)

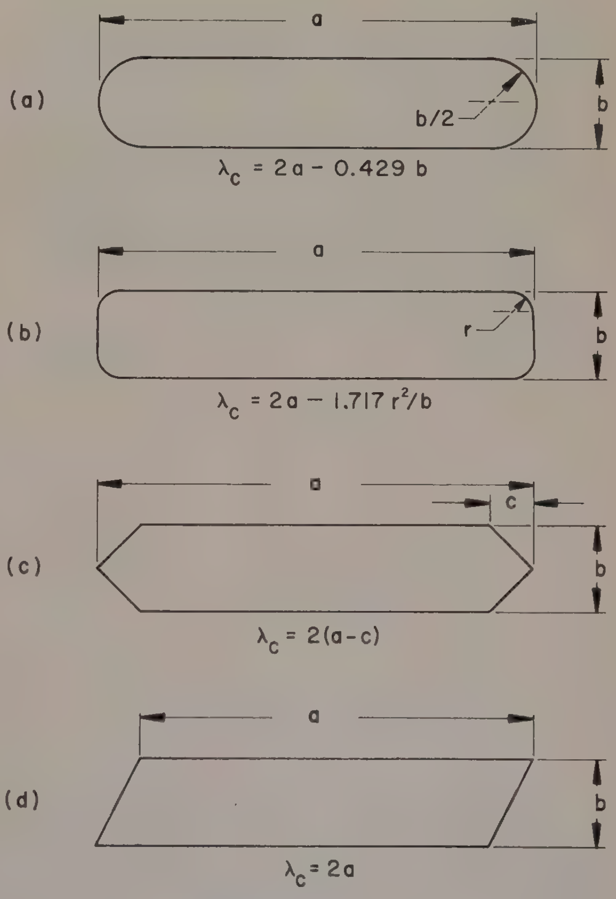

Figure 1 — Four waveguide cross-sections with their approximate cutoff-wavelength formulas.

---

* *The numerical constant in Figure 1 is simply* $2-\pi/2 = 0.429$. *Unfortunately, a different, incorrect value occurs in my article due to a typographical error.*

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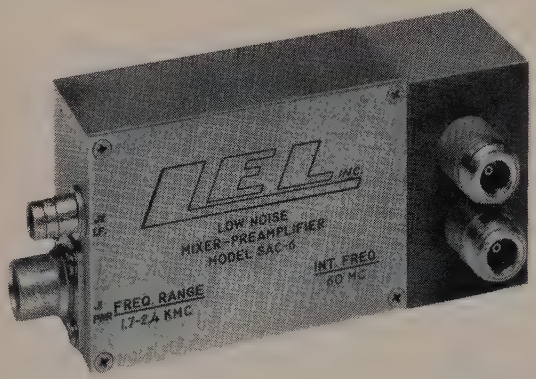

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(*Continued from page 15*)

more exact and complicated solution for that cross s tion recently published by G. R. Valenzuela.[2] The cuto wavelengths differ by only about 0.5% for b/a=0 and the difference vanishes quickly as b/a is decrease

A second example is in the computation of the eleme values of Tchebyscheff arrays, which are widely used the design of directive antennas, multi-hole directio couplers, and stepped transformers. The methods computation with which most microwave engineers a familiar are highly laborious and tedious. Recen however, C. W. Chandler of Rantec Corporation show me a surprisingly simple set of formulas for the eleme values. They are known to some antenna engineers w driven hard by the need of computing very large arra went to particular lengths to discover a simple meth The general formula was published by G. J. van d Maas in the Journal of Applied Physics.[3] However, t viewpoint and symbolism were highly mathematical a formalized, with the result that the simplicity and val of the final results were not readily apparent to t casual microwave engineer who might have found way into that Journal's pages. In some instances, the r sults were ignored because they were mistakenly believ to be approximations valid only when the number of e ments was large. The exact formulas for the cases n= to 8 are given in Table I in a form suited to stepp transformers and multi-hole directional couplers. either case, the equal-ripple band lies between ϕ_1 a $180° - \phi_1$, which are, respectively, the electrical-leng separations between adjacent array points at the low and upper limits of the equal-ripple range.

The third example concerns the time delay or pha slope of a filter ($t_d = d\phi/d\omega$). About six months ago I c rived the following surprisingly brief formula for t time delay at center frequency of a narrow-band ban pass filter:

TABLE I.
Tchebyscheff — Array Elements, n=3 to 8.

n	Relative Element Value ($a_1 = a_{n+1-i}$)
3	$a_1 = 1$ $a_2 = 2\sin^2\phi_1$
4	$a_1 = 1$ $a_2 = 3\sin^2\phi_1$
5	$a_1 = 1$ $a_2 = 4\sin^2\phi_1$ $a_3 = 4\sin^2\phi_1 + 2\sin^4\phi_1$
6	$a_1 = 1$ $a_2 = 5\sin^2\phi_1$ $a_3 = 5\sin^2\phi_1 + 5\sin^4\phi_1$
7	$a_1 = 1$ $a_2 = 6\sin^2\phi_1$ $a_3 = 6\sin^2\phi_1 + 9\sin^4\phi_1$ $a_4 = 6\sin^2\phi_1 + 12\sin^4\phi_1 + 2\sin^6\phi_1$
8	$a_1 = 1$ $a_2 = 7\sin^2\phi_1$ $a_3 = 7\sin^2\phi_1 + 14\sin^4\phi_1$ $a_4 = 7\sin^2\phi_1 + 21\sin^4\phi_1 + 7\sin^6\phi_1$

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$$t_{do} = \frac{\omega'_1}{\omega_2-\omega_1}\sum_{i=1}^{n} g_i \text{ seconds.}$$

ie symbols are defined as in my earlier articles on coup-l-resonator filters.[4,5] $g_1, g_2, \ldots g_n$ are the element lues of the prototype low-pass filter having one-ohm minations. $\omega_2-\omega_1$ is the angular-frequency bandwidth the band-pass filter corresponding to ω'_1 of the low-ss-prototype filter (i.e., ω'_1, ω_1 and ω_2 are measured at e same insertion-loss level). Because of its simplicity d usefulness I would hesitate to assume that this for-ula has not been published before, but I have not my-lf seen it in print.* If it has been published, I would ess that it is buried deep in the technical graveyard as r as most microwave engineers are concerned.

References

S. B. Cohn, "Microwave Coupling by Large Apertures," Proc. IRE, vol. 40, pp. 696-699; June, 1952.

G. R. Valenzuela, "The Cutoff Wavelengths of Composite Waveguides," IRE Trans., vol. MTT-9, pp. 363-364; July, 1961.

G. J. van der Maas, "A Simplified Calculation for Dolph-Tchebyscheff Arrays," Jour. Applied Phys., vol. 25, pp. 121-124; January, 1954.

S. B. Cohn, "Direction-Coupled-Resonator Filters." Proc. IRE, vol. 34, pp. 187-196; February, 1957.

S. B. Cohn, "Phase Shift and Time-Delay Response of Microwave Narrow-Band Filters," Microwave Journal, vol. 3, pp. 47-51; October, 1960.

Dr. T. R. O'Meara, of Hughes Research Laboratory, who is very familiar with the literature of circuit theory, has told me that he had independently derived this formula and has also never seen it in print.

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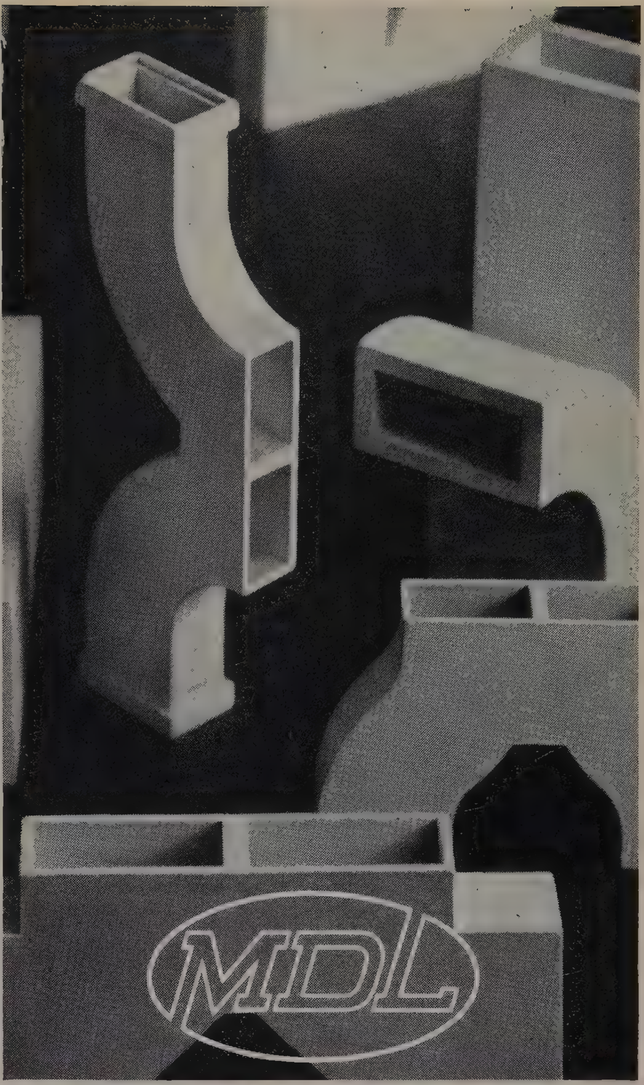

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Industry News

S-F-D ACQUIRES PERENIC TO DEVELOP MICROWAVE SUB-SYSTEMS

Lawrence J. Perenic has joined S-F-D laboratories, Union, N. J., as senior project engineer, sub-systems. He will be engaged primarily in the development of microwave sub-systems. S-F-D laboratories, a subsidiary of Varian Associates, is engaged in research and development of microwave tubes and other electronic devices. These devices are essentiailly components which generate, amplify and detect microwaves in radar and communications systems.

Mr. Perenic was formerly associated with ACF Electronics Division of ACF Industries, Inc., Paramus, N. J., as director of the microwave equipment laboratory. His work there included the development of solid-state tracking beacons as well as related command and telemetry sub-systems for the Discoverer, Mercury and Minuteman missile programs.

He received his degree in Electrical Engineering from Brooklyn Polytechnic Institute in 1943, where he later taught in the evening school. He is a Senior member of the IRE, as well as a member of the Professional Group on Microwaves and Microwave Techniques, and a member of the Professional Group on Engineering Management.

— *m w j* —

CUMPSTON DESIGNATED ENGINEERING MANAGER BY I-T-E

Sam E. Cumpston has been appointed engineering manager for the Special Products division of I-T-E Circuit Breaker Co., Philadelphia, Pa.

Previously Mr. Cumpston was with the General Electric Company where he was manager project engineering, Defense Systems Department, Radnor, Pa., for two years; and manager facilities engineering, Aircraft Nuclear Propulsion Department, Cincinnati, Ohio, four years.

Mr. Cumpston attended Reed College, Portland, Ore., before receiving appointment to West Point where he received a BS degree in 1942. He was awarded his MS at the University of Chicago in 1948.

He is a member of the American Ordnance Association, the Association of the Army of the United States, and the American Management Association.

— *m w j* —

ROE WILL HANDLE SALES FOR AIRTRON

J. Robert Roe has been appointed general sales manager and elected a vice president of Airtron, Morris Plains, N. J., a division of Litton Industries, it has been announced by William F. Boyd, Airtron general manager. In his new position, Roe will be responsible for all of the company's sales, including Linden, West Coast and the Advanced Devices Laboratory.

Roe joined Airtron in March, 1960, as manager of the Microwave Components product group of Airtron. Prior to this he was with I.T.T.-Kellogg, where he was responsible for the firm's sales activities in 13 Southern states. He also held a number of other sales and management posts with I.T.T.

Roe is an electrical engineering graduate of Iowa State University and served during World War II with the Signal Corps and Military Intelligence Division.

— *m w j* —

(*Continued on page 20*)

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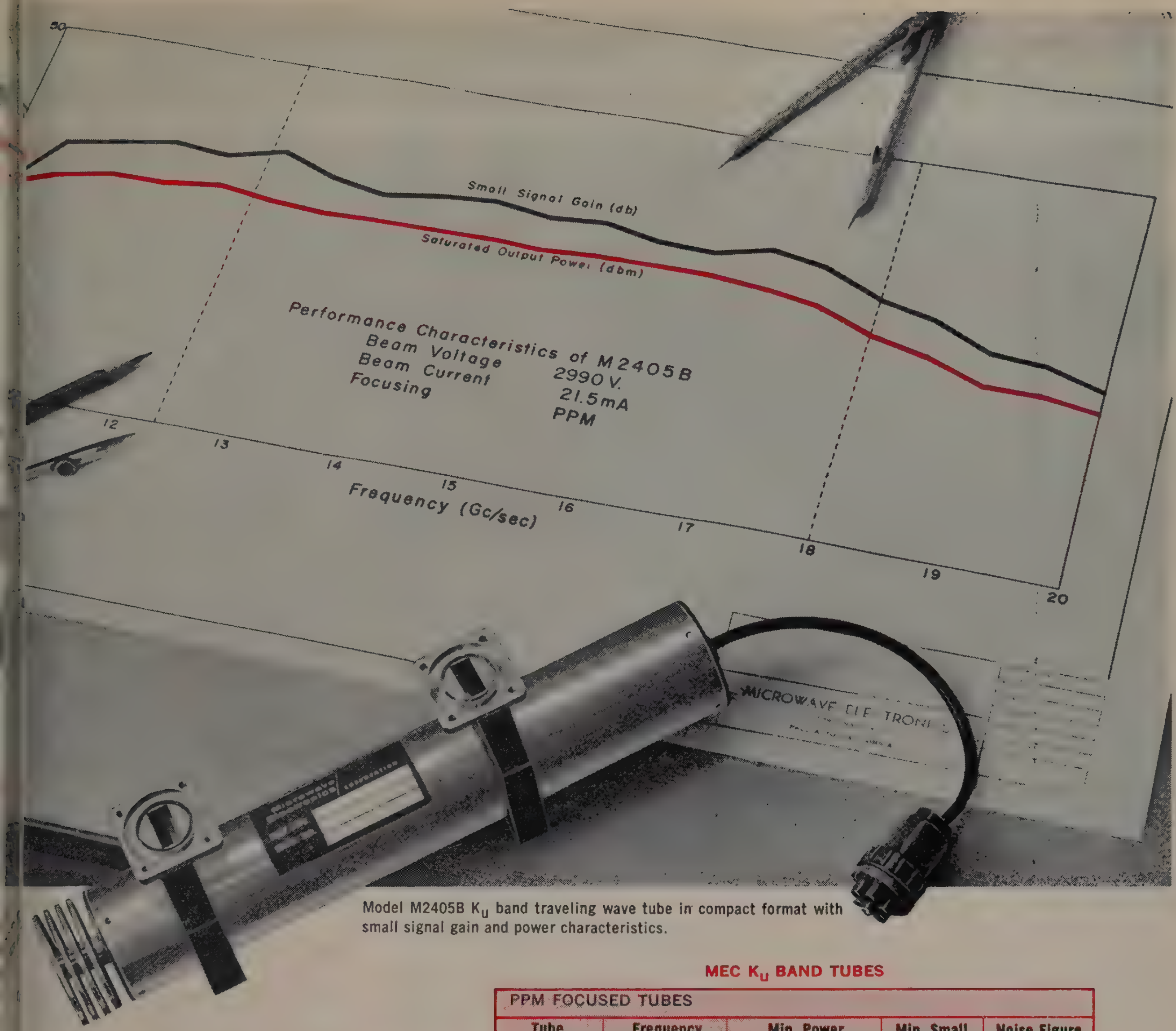
output over the 24 to 36 Gc region.
Other tubes in the MEC K_u band fami
described in the accompanying table.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Small Signal Gain (db)
Saturated Output Power (dbm)
Performance Characteristics of M2405B
Beam Voltage 2990 V.
Beam Current 21.5 mA
Focusing PPM
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13
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19
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Model M2405B K_u band traveling wave tube in compact format with small signal gain and power characteristics.

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M2114G	12.4 - 18.0	5 mw	25 db	20 db
M2208B	12.4 - 18.0	10 mw	30 db	30 db
M2405B	12.4 - 18.0	1 watt	30 db	35 db
M2405H	10.0 - 20.0	1 (12.4 - 18) watt 0.250 (10 - 20) watt	30 db 25 db	35 db
SOLENOID FOCUSED TUBES				
M2114A	12.4 - 18.0	5 mw	25 db	12 db
M2114F	12.4 - 18.0	5 mw	25 db	17 db
M2208A	12.4 - 18.0	10 mw	30 db	30 db
M2405F	12.4 - 18.0	1 watt	30 db	35 db

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onmental extremes. For military applica-
tubes can be provided to satisfy the re-
ments of MIL-E-5400, Class 2. Tubes have
tested at 20 g shock and 15 g vibration
5 to 2000 cps with no performance degra-
n.

More Example of MEC Capability

new K_u band family of traveling wave tubes
e more example of MEC's ability to develop
produce tubes for difficult frequency ranges.
tubes are reproducible in production quan-
because their metal ceramic format and
mic rod supported precision helices ensure
lity and dimensional accuracy.

lts obtained in the K_u band assure similar
ess in the production of broadband traveling
tubes for higher K band frequencies.

TO KEEP POSTED *on current and new developments at MEC, you are invited to ask for a copy of our new catalog. For your copy, call your nearest MEC engineering sales representative or write directly to us.*

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Circle Reader Service Card 11

(*Continued from page 18*)

LINCOLN LAB ENGINEERS FORM ELECTRONIC SPACE STRUCTURES CORP.

A group of engineers, formerly members of M.I.T.'s Lincoln Laboratory, have formed Electronic Space Structures Corp., West Concord, Mass., to do research, development and production of large precision antennas, space frame radomes and shell structures.

Joseph A. Vitale, formerly head of the engineering division of Lincoln Laboratory, is president of ESS Corp.

Antennas for defense radars, microwave and satellite communications, and radio-astronomy are among the specialties of this new firm. The staff of ESS Corp., are also well known for their pioneering work in the development and design of Metal Space-Frame Radomes, the shelters required to protect these antennas from wind, weather and nuclear blast effects.

Albert Cohen, formerly chief of radome design, is vice president of the new corporation. Other founders from Lincoln Laboratory are Phillip Davis and S. C. Nilo.

— *m w j* —

ALFRED COMPLETES NEW PLANT

Alfred Electronics has announced completion of a modern new plant in Palo Alto, Cal.

Containing 32,000 square feet, a 300 per cent increase in size over the firm's previous facility, it is located at 3176 Porter Drive, Stanford Industrial Park. The new plant will allow Alfred to substantially increase production of quality broadband microwave instruments and power supplies.

Since its founding in 1955, Alfred has grown rapidly; sales during fiscal 1960-61 were 79 percent higher than the previous year.

— *m w j* —

HARVEY - WELLS MARKS ADVANCE IN HIGH FIELD SOLENOID MAGNETS

Harvey-Wells Corp., Magnetics Division, Framingham, Mass., announces the successful installation of a new type solenoid magnet capable of providing ultra high field strengths across large working diameters with lower power requirements.

The magnet was designed in conjunction with Professor F. Bitter of the MIT Magnet Lab and utilizes a low carbon steel jacket around the solenoid as a return path.

Designated the Model HF-26, the magnet is now being used for the study of magneto resistances and resonant frequencies in solids and semi-conductor materials at both depressed and elevated temperatures. The bore size (2 inch diameter by 6 inch length) provides ample room for samples in the order of one-half inch cube, together with any necessary low temperature apparatus.

A special steel stand facilitates easy access to the entire bore area. Typical performance parameters are: 52 kilogauss at 240 kilowatts with a 2 inch bore; over 95 kilogauss calculated for a 1 inch bore at 500 kilowatts power.

— *m w j* —

McMURROUGH PROMOTED AT RCA ELECTRON TUBE DIVISION

Promotion of Robert W. McMurrough to the post of engineering leader in Microwave Tube Operations of the RCA Electron Tube Division, Harrison, N. J., has been announced by H. K. Jenny, manager, Microwave Engineering.

In his new position, Mr. McMurrough will lead the group of engineers who design and develop RCA's low-noise and medium-power traveling-wave tubes. A number of these tubes are used in this country's defense and communications systems.

Mr. McMurrough joined RCA in 1958 as a Project Engineer in the Microwave Design and Development group. Before his association with RCA, Mr. McMurrough was employed as a traveling-wave-tube design engineer by the Sperry Rand Corporation. Prior to that, he was a member of the Applied Physics group of the Vitro Laboratories where he worked in chemical physics, mass spectrometry, and on underwater weapon systems.

Mr. McMurrough received a BS and an MS in physics from Fordham University in 1949 and 1950. He also attended New York University and the Brooklyn Polytechnic Institute.

He is a member of the Institute of Radio Engineers and a member of the Institute's Professional Groups on Electron Devices and Microwave Theory and Techniques. He has presented papers on traveling-wave tubes before conferences of the Professional Group on Electron Devices and the American Institute of Electrical Engineers.

— *m w j* —

(*Continued on page 39*)

Inquire about Sperry Tubes from these convenient Cain & Company offices

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VI 9-6781

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HN 6-0600

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3508 Devon Avenue
OR 6-9500

St. Petersburg, Florida
410 — 150th Avenue
Madeira Beach Prof.Bldg.
391-0151

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Dayton, Ohio
Phone RO 7-8661

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Phone 268-5300

San Francisco, California
Phone YO 8-0995

San Diego, California
Phone HU 8-0665

Seattle, Washington
Phone MA 3-3303

SPERRY ELECTRONIC TUBE DIVISION
SPERRY RAND CORPORATION

PERRY ELECTRONIC TUBE DIVISION microwave memo

perry adds high-power pulsed TWT's o list of tubes available in 30 days

move to simplify design problems present and future radar systems, rry Electronic Tube Division of rry Rand Corporation has added high-power pulsed traveling wave es to the list of advanced microve tubes available in 30 days.

he two tubes covered by the anncement—the STL-114 and the -152—operate in L and C bands, ectively. They are typical of a of pulsed TWT's ranging from through V bands which Sperry rs on a firm delivery date basis.

EASY RADAR APPLICATION

perry's pulsed TWT's are admiry suited to the demands of applica in phased array radars, height ders, search, ECM, and other radar plications. Widely varied in-system erience has proved that their relility, long life, high power, high n, and extreme broadband operation ke them ideal for radar use.

esign features of this tube family nimize the necessity for system ustments in the field. Among these tures are broadband response, stant voltage operation, and short cuit stability.

VERIFIED RELIABILITY

These pulsed TWT's, produced at erry's Great Neck, N. Y., facility, ve compiled an impressive record in-system experience. Such experice has proved that their resistance shock and vibration damage, their erent indifference to ambient conions, and their mounting flexibility ake them ideal for ground or borne application.

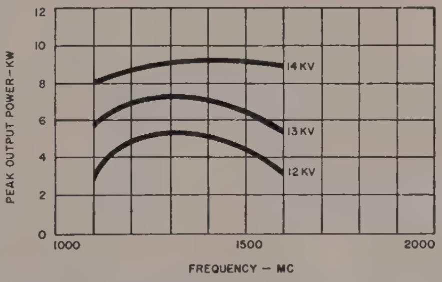
Place your order with your Cain & mpany representative. His phone mber appears in the adjacent colnn. Tubes are available within 30 ys after receipt of order.

FREE TECHNICAL INFORMATION on e Sperry line of high-power pulsed veling wave tubes may be obtained writing to Sec. 604, Sperry Electronic be Division, Gainesville, Florida.

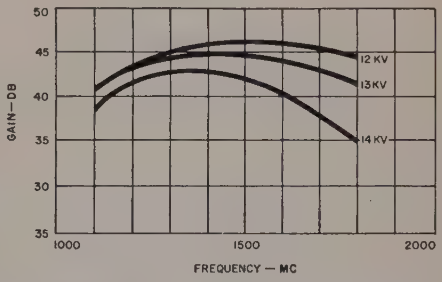
V BAND CAPABILITY

Among Sperry's other interesting tivities in pulsed TWT's is the exnsion of capability into the V Band 26.5 to 40.0 kMc. Although these forts are largely classified, inquiries e invited from those who have the ecessary clearance and need to know.

FACTORY ALIGNMENT of a Sperry TWT within its focusing solenoid greatly simplifies field maintenance. Once this operation has been performed by a skilled Sperry technician, the assembly is self-aligning.



Typical saturated power output vs. frequency for a pulsed Sperry TWT.



Typical small signal gain vs. frequency for a pulsed Sperry TWT.

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GAINESVILLE, FLA. / GREAT NECK, N. Y.
SPERRY RAND CORPORATION

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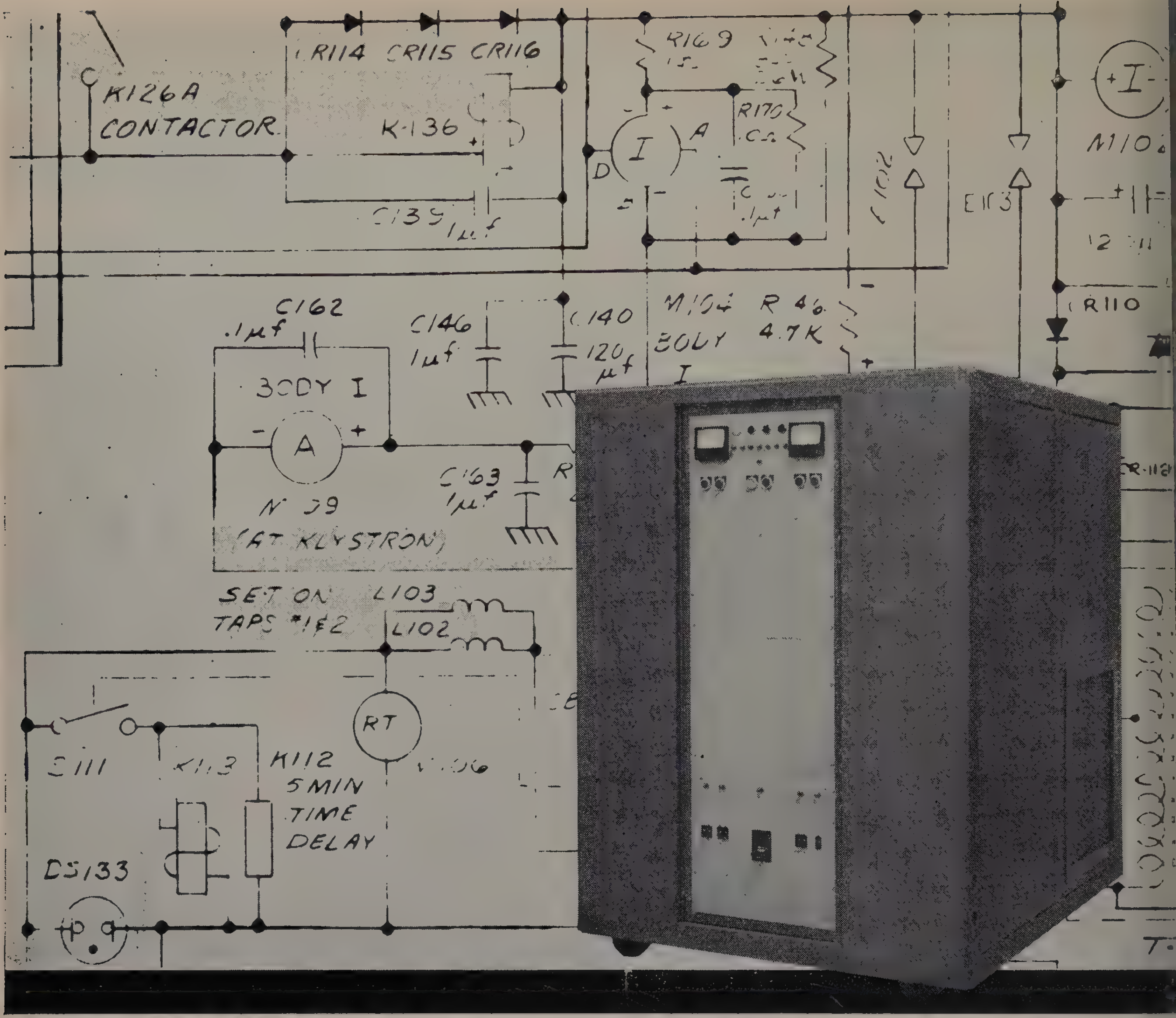
K126A CONTACTOR
CR114 CR115 CR116
K-136
C139 1μf
R169
R170
M110
R110
C162 .1μf
C146 1μf
C140 120μf
M104 BODY I
R46 4.7K
BODY I
M39 (AT KLYSTRON)
C163 1μf
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L103
L102
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S111
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K112 5 MIN TIME DELAY
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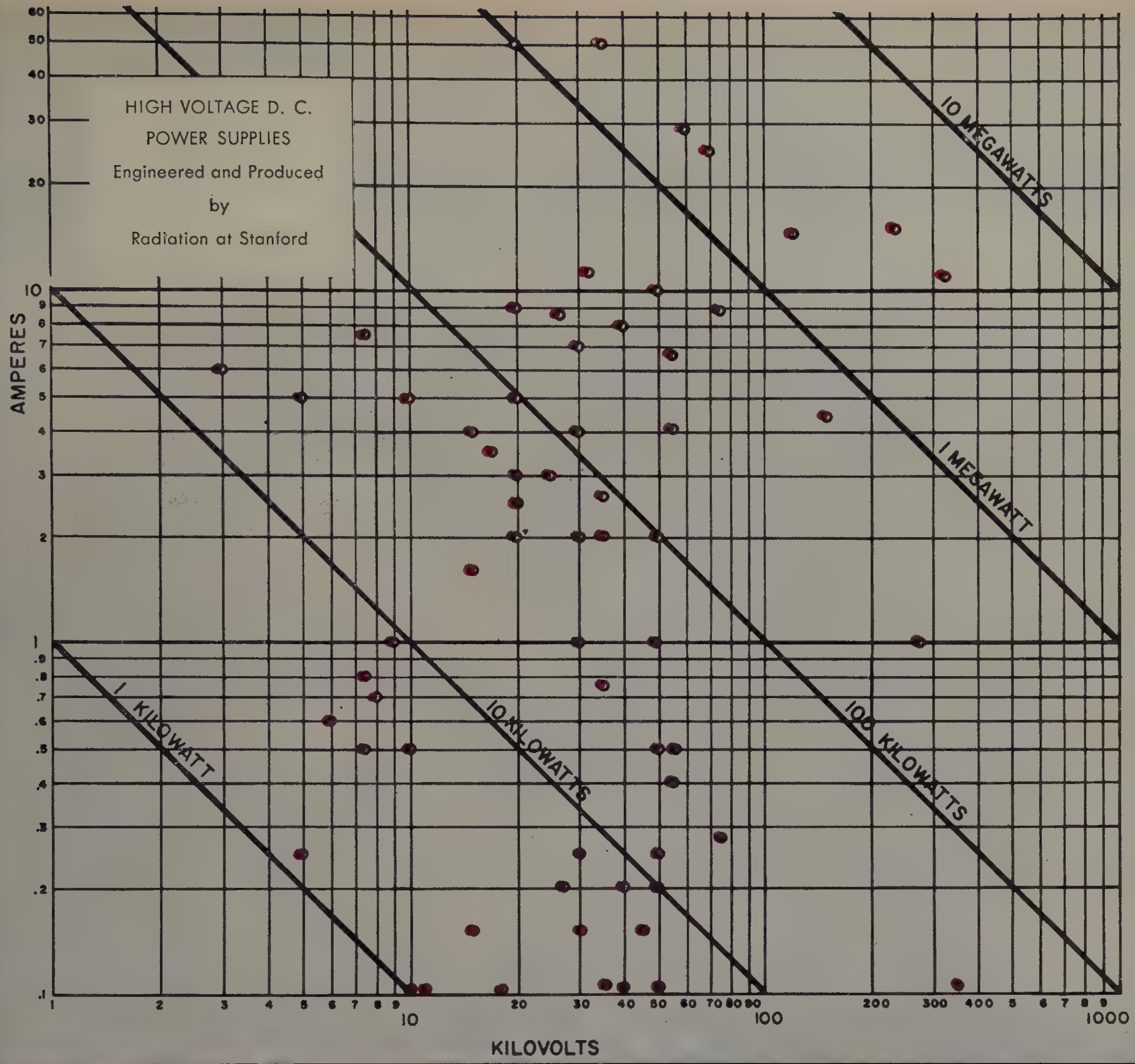
For a special brochure with complete technical infor-mation on our standard line of "power" supplies, writ Radiation at Stanford, 3180 Hanover Street, Palo Alto California.



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If your project calls for unusual power and an early completion date, bring your problem to us. For specific information, call or write Radiation at Stanford, 3180 Hanover Street, Palo Alto, California.

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microwave measuring equipment

for the 8-4-2 mm bands

The outstanding quality and precision of Philips' microwave components for the 8, 4 and 2 mm bands are in accordance with the high standards set by advanced research.
The range of components is continuously being extended.

8 mm band (31—36 kMc/s)

PP 4420Q	ferrite isolator
PP 4382Q	standing wave detector
PP 4300Q	broadband wavemeter
PP 4270Q	sliding screw tuner
PP 4260Q	calibrated short circuit
PP 4222Q	adjustable crystal mount
PP 4200Q	klystron mount
PP 4170Q	matched load
PP 4150Q	rotary attenuator
PP 4130Q	flap attenuator
PP 4090Q	directional coupler
PP 4080Q	horn
PP 4050Q	hybrid Tee
PP 4035Q	twist
PP 4030Q	H-plane bend
PP 4025Q	E-plane bend
PP 4020Q	straight waveguide sections
PP 4020Q/AR	adaptor to flange UG599/U
PP 4020Q/BR	adaptor to flange UG381/U

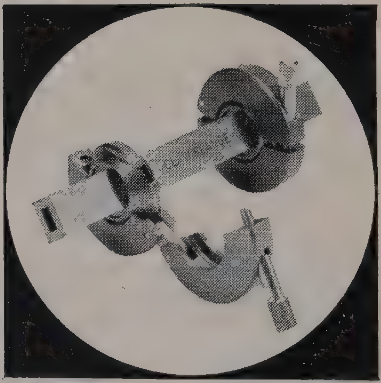
4 mm band (60—90 kMc/s)

PP 4422E	ferrite isolator
PP 4300E	wavemeter
PP 4270E	sliding screw tuner
PP 4260E	adjustable short circuit
PP 4220E	crystal mount
PP 4200E	klystron mount
PP 4170E	matched load
PP 4130E	flap attenuator
PP 4080E	horn
PP 4050E	hybrid Tee
PP 4035E	twist
PP 4034E	H-plane bend 180°
PP 4030E	H-plane bend 90°
PP 4025E	E-plane bend 90°

2 mm band (110—170 kMc/s)

PP 4400B	calibrated variable impedance tuner
PP 4270B	tuner
PP 4260B	adjustable short circuit
PP 4230B	harmonic generator 4 mm - 2mm
PP 4220B	crystal mount
PP 4170B	matched load
PP 4080B	horn
PP 4050B	hybrid Tee
PP 4015E	clamping ring for claw flange
PP 4010E	claw flange

For the 2 and 4 mm microwave components Philips Research Laboratories have developed a waveguide coupling which fully satisfies the special requirements of this frequency range.
The Claw Flange offers amongst other advantages very small reflections (|R|<0.005), compact construction of the microwave component and universal and simple fixing.



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NICOLAAS BLOEMBERGEN

Gordon McKay Professor Applied Physics

HARVARD UNIVERSITY

Cambridge, Massachusetts

By EVARTS ERICKSON

"I think what attracts me most about this field is the rnal fascination of discovering in my laboratory or ted here behind my desk something that no one else fore me has found."

The speaker, Dr. Nicolaas Bloembergen, Gordon Mc-y Professor of Applied Physics at Harvard University, perhaps best known to microwave engineers for his rk with masers. It was Dr. Bloembergen who in 1956 olved the theoretical concept behind the three-level id state maser that now vastly extends the range of dio telescopes.

When we visited Dr. Bloembergen recently in his large rner office in Pierce Hall on the Harvard campus, we re surprised to find a youthful-looking man in shirt-eves, speaking with rather a pronounced accent. Bloem-rgen is a Dutch name, of course, and one's first im-ession is that the professor's features bear a resemblance *National Geographic*-type photographs of Low Country rghers. It seemed to us fitting, also, that a Dutchman ould be responsible for this new device which will en-le man to "hear" the radiation from hydrogen clouds galaxies far beyond the range of any present instru-ents. Did not the Dutchman, Leeuwenhoek, extend an's vision almost to the infinite at the other end of the ale with vastly improved versions of the microscope?

When we mentioned this to Dr. Bloembergen, he ughed. "Certainly it is true that the Netherlands was ce a leader in science," he remarked, "and no doubt ere is a definite relation between prosperity and the chnological vitality of a country. Like the United ates and Russia today. But I am afraid that science Holland has for the last several years fallen behind e times. This is because of the archaic organization the universities based on patterns of the early 19th ntury. Though lately, I must say, they have made rong attempts at reform."

Did he do much teaching, we asked him; and what ought him to Harvard?

"First, to answer your questions in order: yes, I teach three hours a week or one course a semester. I think that's just about the right amount. Perhaps the most important part of my job is guiding from 6 to 10 graduate students through their PhD research work.

"Second, I first came to Harvard to do my own graduat work after the second World War. It was just after what we in Holland call the Hunger Winter. People were so hungry they were eating tulip bulbs. Have you ever tasted them? They are tough like raw potatoes. Even when you have boiled them for hours. To start at the beginning, though, I was born in Dordrecht in 1920 This is just outside the provincial city of Utrecht in western Holland. I was the second of six children. Five of them later completed their academic education. M father was a chemical engineer who later became a business executive in a fertilizer concern."

His boyhood, as he sketched it for us, had been rather idyllic. As a youngster, for instance, he'd been an avid player of field hockey. "Here it is played only by girls," he said, "but there it is a real game. It is the favorite of all the boys and men and we used to play all year

(*Continued on page 26*)

NEW
COMPONENTS
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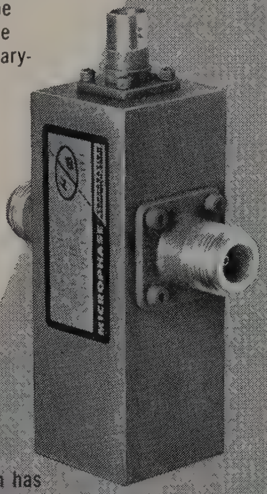
TUNABLE
HIGH-PASS FILTER
MODEL T1582H1

Has 20% passband in the X Band. Cutoff frequency adjustable 8500-9500 mc, the unit has less than 1.0 db insertion loss and provides 50 db minimum rejection 6% away from the pass frequency. The filter is continuously tunable and is equipped with planetary-type dial indicator.



CRYSTAL SWITCH
MODEL XS-12-125

Compact UHF crystal switch has approximately three percent 3-db bandwidth. At the operating frequency, insertion loss is less than 1.5 db in the transmit condition. Isolation on the order of 30-35 db is obtained with proper bias voltage. The unit is switched by applying 0.5-2.0 VDC to the BNC connector.
Crystal switches with similar performance are available in other frequency bands.

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BLOEMBERGEN

(Continued from page 25)

long except for the relatively brief period when sno covered the ground."

We said we'd always thought of Holland as the lan of silver skates. "That's a misconception," he assur us, smiling. "Actually, our climate is quite mild, an it's only perhaps two weeks out of a year when the cana are frozen over so that we can skate. Of course, it is very popular sport, and when it does freeze over, all th schools and offices are given a holiday."

Besides his love of field hockey, he had also been a ardent small boat sailor. It started when he had ha a foot operation and—because he was incapacitated f rougher sports—his father had given him a centerboar sailboat, a twenty-footer, something like a Lightning-cla sailboat in this country. His great sport then had bee sailing up the Rhine, or through the canals, tacking bac and forth in canals sometimes only six times the lengt of his boat. . .

"Why did you decide to study physics?" we asked hi

"I had always been strongly attracted to physics sin youth, though for a while I thought of taking up la guages. But I must say I was rather uneasy—c beginning my physics studies—to read that the beginni student shouldn't think he could become a good physici because he had constructed a good radio. What worrie me about this was that all my experience was complete theoretical. I had never even constructed a radio. M education, in fact, was in an old-fashioned European kin of Latin School where I had studied Latin, Greek, Frenc English and German besides my native Dutch. Certain we had nothing in the way of practical application, a though we did have very good instruction in the science As it turned out, it didn't really make any difference. .

In 1939—just before the storm broke over Europe— young Bloembergen entered the University of Utrech and there he stayed until it closed in 1943. By the he had passed his qualifying examinations for his docto ate and had his *Doctorandus* in physics. This meant h had only to write his thesis in order to get his PhD.

"Legally, I was no longer a student, and was cons quently in less danger of being conscripted for labo service in Germany. Once, the Germans did try to pic my brother and myself with many other students, bu we had had advance warning and had gone into hidin in the countryside at the home of an old aunt. In a fe weeks we returned, and the incident had blown over. was freer to walk around the streets than most Dutch men, because my identity card stated that I was a mem ber of the university fire brigade. Then in the winte of '44, Montgomery tried to seize a bridgehead across th Rhine at Arnhem, and the Germans reacted ferociousl to a nationwide Dutch railway strike that had been calle to aid the allied effort.

"The Germans cut off all food shipments to the area, Dr. Bloembergen recalled. "Our total ration was 40 calories a day and, as you probably know, subsistenc minimum is generally considered to be 1200 to 160 calories a day. This in one of the most densely populate regions in the world—with major cities like Amsterdam Rotterdam, Utrecht, and the Hague. . ."

(Continued on page 30)

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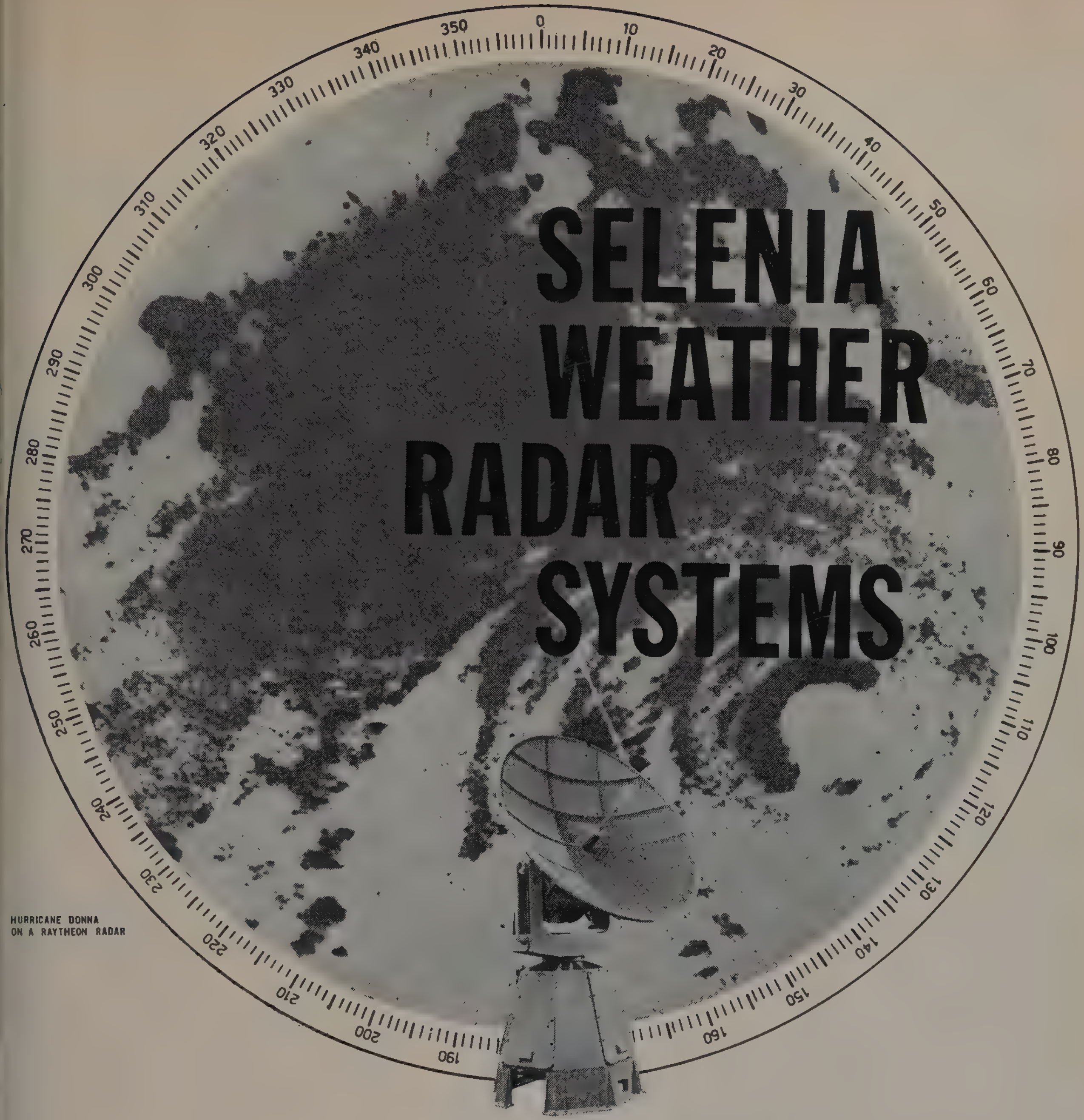

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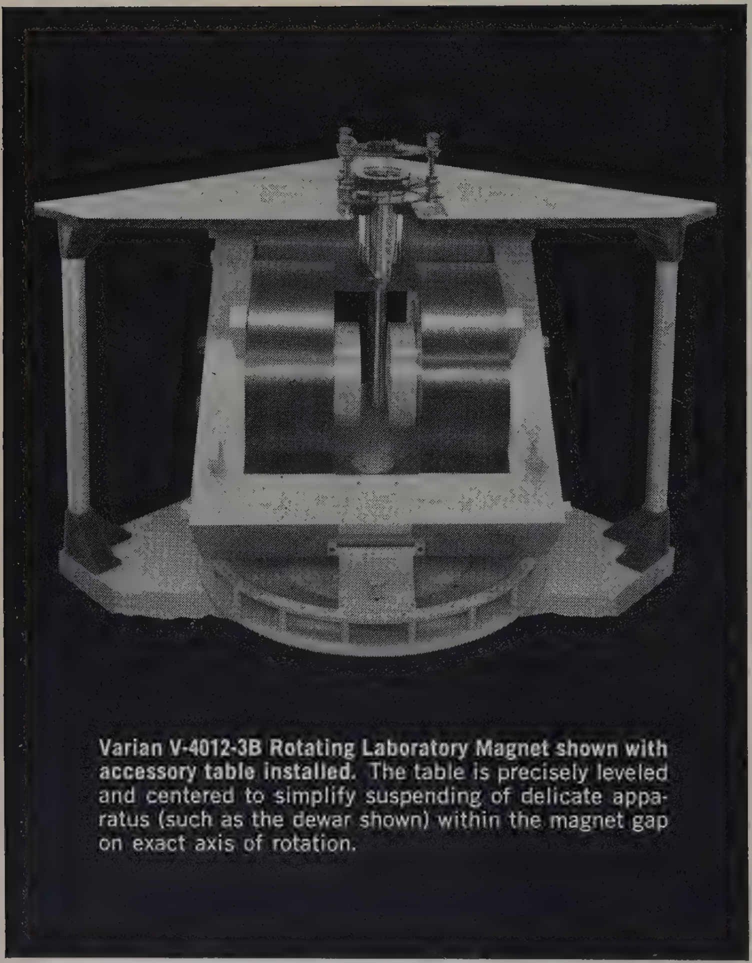
FROM VARIAN

12-INCH PRECISION LABORATORY MAGNETS

LARGE HOMOGENEOUS MAGNETIC FIELDS


Varian V-4012-3B Rotating Laboratory Magnet shown with accessory table installed. The table is precisely leveled and centered to simplify suspending of delicate apparatus (such as the dewar shown) within the magnet gap on exact axis of rotation.

Field homogeneity in a useful third dimension

Presented here for the first time, a three-dimensional plot from a 12-inch Varian Magnet reveals over 100 cc of highly homogeneous field available to the experimental physicist. This volume is a technical accomplishment because field homogeneity normally falls off rapidly with increasing gap width. It demonstrates again how Varian's long experience puts extra value into these magnet systems.

Easy accommodation of bulky experimental apparatus

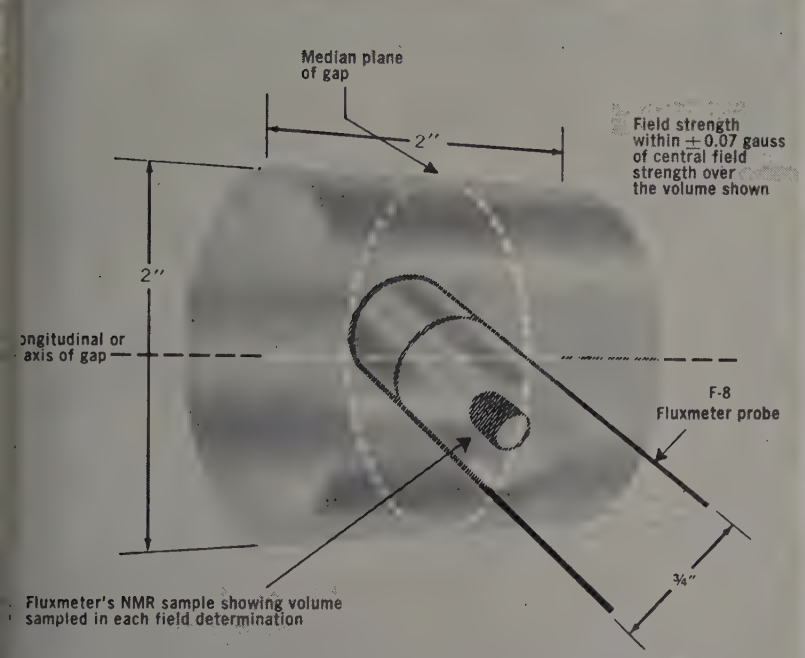
The large field shown is highly useful in two respects. The over-all air gap width of nearly three inches is sufficient to hold glass dewars and other apparatus surrounding the field-sensitive sample or object. And your sample itself may be of any bulk and dimensions up to those shown and still fall inside a field homogeneous within ±0.07 gauss of the 3550 gauss central field strength. Outstanding performance is also attainable at other field strengths.

A versatile range of other capabilities

Much higher magnetic field strengths are available by purchase of additional pole cap configurations for smaller air gaps. The extra cost is nominal. And the magnet provides a useful volume of homogeneous field at these higher strengths. Thus as a long-range investment a Varian Magnet is adaptable to needs unforeseen at time of purchase.

Write today for the new 32-page magnet brochure which gives specifications on Varian's full magnet line. Address Instrument Division.

N WIDE AIR GAPS


Median plane of gap
2″
Field strength within ±0.07 gauss of central field strength over the volume shown
2″
ongitudinal or axis of gap
F-8 Fluxmeter probe
¾″
Fluxmeter's NMR sample showing volume sampled in each field determination

More than 100 cc of homogeneous magnetic field within 3-inch central air gap. Three-dimensional cylindrical field of Varian 12-inch magnet shown full scale in oblique view; ring shim pole caps used; field strength 3550 gauss.

Probe extension cables to 100 feet in length available as accessory.

VARIAN F-8 FLUXMETER with new crystal frequency control. Time stability and accuracy enable the Varian Fluxmeter to make homogeneity field plots. The fluxmeter probe (at left) is shown extended into the magnet gap as is usually done in making the field plot.

The F-8 can provide direct stabilization of magnetic fields by utilization of the D.C. error signal output. The F-8 is perfectly matched to the Varian 6- and 12-inch magnet system power supplies, and readily adapts to others.

VARIAN associates
PALO ALTO 34, CALIFORNIA

MR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

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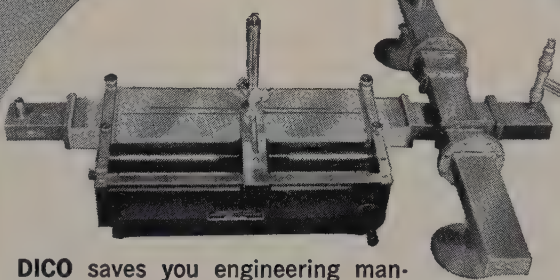

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WR229 WAVEGUIDE COMPONENTS

DICO saves you engineering man-hours and machine-hours. Once again, realizing the high cost of producing prototypes or single microwave units, DICO's research and engineering staff has supplemented their already broad line of products with a complete line of WR229 Microwave Components. This means you save invaluable time and manpower by purchasing DICO "off the shelf" items. DICO'S broad technical background and extensive experience will solve your intricate designs and special applications problems.

Important contributions, such as this, are a tradition at Diamond Antenna. DICO engineers, using the finest facilities available to the industry, were responsible for many "firsts" in missile and aircraft communications, shipboard and land based radar, and microwave equipments. Today, DICO is one of the foremost producers in combining waveguide, coaxial, antenna and rotary joint components.

For complete information on the WR229 series and other DICO products and services, write

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35 River Street
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DICO

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BLOEMBERGEN

(*Continued from page 26*)

Before the war, Bloembergen had intended to do
graduate work in France or Germany. Since that w
clearly impractical afterwards, he decided to try Ameri
Although he and some twenty other students had be
picked by the Dutch Department of Education to c
tinue their studies abroad, arrangements were up to h
Thus, in May 1945, he wrote letters of application
three American universities. One went to Harvard, o
to Berkeley, and one to Chicago.

"Some friends of mine who were studying Chin
literature and U. S. history had no trouble being
cepted. But to apply to study physics in the U. S.
the time of the Manhattan Project. . . well, that w
another story. The University of California at Berke
answered courteously that no aliens could be admitt
to the campus while war with Japan was still going c
The University of Chicago did not answer at all."

Fortunately, Harvard invited him to submit
transcript of his record and then accepted him. . .b
other obstacles presented themselves.

Where could he get the dollars that the transatlan
carriers demanded?

At that time, the only Dutchmen granted permits
their government to convert their guilders into dolla
were tulip growers. They alone had a commodity—tul
bulbs—that would bring their country the needed ha
currency.

Taking his courage in both hands, Bloembergen we
to see a bureaucrat of the Dutch Department of Educ
tion. "Look," he said stubbornly, "you think I'm go
enough to go. My father is willing to advance me so
guilders, and this American university has accepted m
The least you can do is give me a permit so I can b
the dollars."

The Dutch love stubbornness. Impressed, the educ
tion official produced the needed permit and in Februar
1946, Bloembergen found himself in Cambridge, Mass
chusetts, at what he now regards as an exceedingly pro
tious time.

Harvard was crowded with students returning fro
all corners of the globe, many of whom were beginni
their graduate work together. Essentially, however,
one had had Bloembergen's laboratory experience. As
result, he almost immediately started doing experiment
work as a research assistant in the physics departme
Besides, he had the extreme good fortune to be worki
under Professor Edward M. Purcell.

Six weeks earlier, Purcell had made his great discove
(arrived at independently by Professor Felix Bloch
Stanford; later they would share the Nobel Prize in phy
ics) of nuclear magnetic resonance. Bloembergen almo
immediately started doing experimental work in this e
citing new field. Two years later he received his docto
ate from the University of Leyden where he was resear
associate of Professor Gorter at the Kamerlingh Onn
Laboratory. Harvard then invited him to return on
special three-year fellowship as a Junior Fellow in t
Society of Fellows.

(*Continued on page 32*)

A statement about the Zenith electron-beam parametric amplifier–

. . . A New component in Radar, Telemetry, Satellite- and Deep-Space-Probe Tracking and Ranging, Radio-Astronomy, Radio-Navigation, Phase- and Frequency-Modulation Communications Systems.

every new development, there comes a time for a review of progress and a look into the future. That time has come for the electron-beam parametric amplifier—the Zenith "EBPA." As a low-noise amplifier, its noise performance is in the 1 db range, with gain up to 45 db. Its utility and value have been provided in field tests of many systems.

THIS IS WHAT THE EBPA DOES, how it has proved itself, and what we believe it can do—

CAPSULE DESCRIPTION OF OPERATION

The EBPA system consists of a quadrupole-amplifier tube operating in a magnetic field, an RF pump generator, and a power supply. Within the tube, the signal is coupled onto the electron beam and amplified by the action of the quadrupole structure, using energy from the RF pump generator. The power supply furnishes voltages for the tube electrodes, solenoid, and RF pump generator.

PERFORMANCE CHARACTERISTICS

Noise Figures Obtainable: From 0.6 to 1.5 db, as measured with broadband noise source. No cryogenic apparatus is required. Single-channel noise figure depends on antenna and application—typically, 2.5 db. Mixer noise is negligible because of high gain.

Range of Center Frequencies: 350 to 1800 Mc (tubes of higher frequency are in development).

Phase Stability: Better than 1°.

Amplitude Stability: ±0.05 db has been measured.

Gain: Usually operated at 25 db; gain up to 45 db has been obtained.

Bandwidth: Up to 10 per cent of operating frequency.

OPERATING FEATURES

The EBPA not only provides low-noise performance, but also offers characteristics unattainable with other low-noise systems, such as:

- Unconditional stability with respect to input and output terminations without the use of a circulator.
- High gain, with complete freedom from regenerative effects.
- Relatively large bandwidth independent of gain; no tuning required.
- Freedom from burnout; insensitivity to overload—several watts average, several hundred watts peak power.
- Fast recovery time (30 nanoseconds).

SYSTEM DESIGN CONSIDERATIONS

System Protection. The EBPA tube not only withstands large amounts of incident overload power but also reflects most of it. In radars, this characteristic means that TR tubes can be eliminated. In addition, the EBPA protects mixer crystals from "spikes," and eliminates need for harmonic filters and shutters; also, down time and maintenance are reduced.

Ease of Installation. EBPA systems have been installed in minutes and have operated immediately. Once installed, they are very stable and operate for long periods without adjustment.

Reliability. Life expectancy of the EBPA tube is of the order of 10,000 hours.

Adaptability to Systems. The EBPA is normally installed as a simple insertion unit in the system front end and does not entail radical alteration of existing designs.

APPLICATIONS

Radar: Search Type. In tests conducted on eight such radars, MDS improvements of 4 to 10 db were attained.

Radar: Phased-Arrays. The unusual phase and amplitude stability of the EBPA makes it a natural candidate for application as a preamplifier in phased-arrays. Power supply and RF pump are common to all units in such an installation to insure maximum uniformity. An experimental installation of this kind, involving 16 EBPA units, was recently delivered. (Data on this installation will be available soon.)

Tracking System. A set of three EBPA units has been completed for use in a tracking system. A common power supply and common RF pump were provided. Maximum noise figure of the equipment as shipped is 1.2 db. Lab tests indicate the equipment will meet the differential phase stability requirements for monopulse applications. (Data on this installation will be available soon.)

Radio-Astronomy. The EBPA has found its way into a number of big dishes used in radio-astronomy. It is usually installed as close to the feed as possible to cut transmission losses. It has been used for hydrogen-line work at 1420 Mc, and to amplify radar returns from the planet Venus at approximately 400 Mc. The high phase stability and large bandwidth have proved particularly useful in interferometer applications.

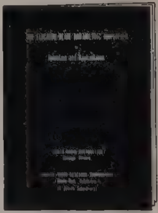
Radio-Navigation System. When installed in a Tacan ground station receiver, the EBPA improved MDS by 4.5 db.

Radio Direction-Finder. When installed in a Rawin set, the EBPA improved MDS by 15.0 db.

P-M and F-M Systems. In phase-lock receiving systems, it is feasible to use synchronous pumping with a degenerate EBPA, resulting in an effective noise figure of about 1 db. Applications are space-probe tracking, scatter communication, and in general, all systems using only phase or frequency modulation.

COMING SOON

- EBPA tubes for operation at C-band.
- Tunable EBPA tubes: single-knob tuning will cover range of over 100 Mc.
- A metal-ceramic tube for operation from 400 Mc to about 1500 Mc; features are external tuning, lower cost, and greater resistance to adverse environment.
- More compact power supply.
- Non-degenerate EBPA tubes.



If you wish more information, send for booklet **The Electron-Beam Parametric Amplifier, Operation and Applications.** Please address requests and any questions or comments to the Special Products Division, Dept. S-12, Zenith Radio Corporation; 6001 W. Dickens Ave.; Chicago 39, Illinois.

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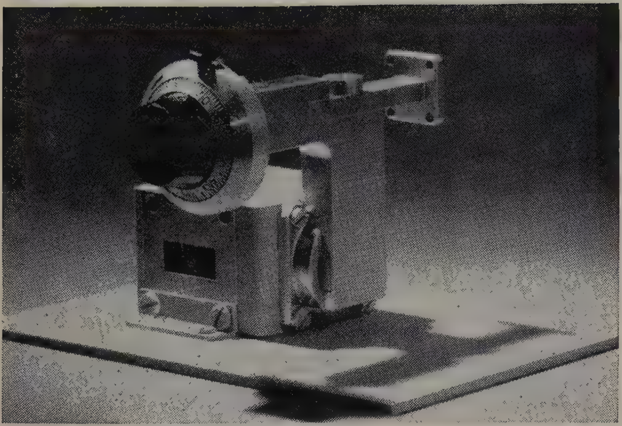
NOW . . . X BAND NONDEGENERATE PARAMETRIC AMPLIFIERS with a tuning range of 1.1 Gc!



Single-knob tuning over a range of 1.1 Gc in the X band is featured in this nondegenerate parametric amplifier by Texas Instruments Incorporated. Bandwidth is 30 mc and gain is 15 db. Noise figure, including circulator loss and normal second stage, is 4.5 db. Its broadband signal frequency response and fixed pump frequency give you dependable operation with a minimum of tuning adjustment.

TYPICAL MODEL X-22 SERIES SPECIFICATIONS

Mode of Operation	Nondegenerate
Tuning Range	8.5 to 9.6 Gc
Bandwidth	30 mc
Gain	15 db
Noise Figure (Including circulator loss and normal second stage)	4.5 db
Pump Frequency	24.0 Gc
Diode	Texas Instruments Gallium Arsenide Diode
Pump Power	50 mw

For more details about this amplifier or other Texas Instruments parametric amplifiers operating at L, S, C, and X bands, contact RADAR AND MICROWAVE PRODUCTS DEPARTMENT.

APPARATUS DIVISION
TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
P. O. BOX 6015 DALLAS 22, TEXAS

Circle Reader Service Card 29

BLOEMBERGEN

(*Continued from page 30*)

"This often functions as a recruiting ground fo Harvard faculty," Professor Bloembergen told me, "an that is how it turned out in my case. You might b interested to know that I also got offers from Berkele and from Chicago."

"Did you reply?" we asked him.

"I replied," he grinned. "But seriously, I think I w very fortunate at Harvard. Particularly in my association with Professor Purcell."

"Do you think there is any common criterion for th great scientists?" we asked him. "Is there any set o characteristics they seem to possess?"

"I have not read the biographies of the great scientists," he confessed. "But if you mean the Nob Laureates, no. The characters of the Nobel Prize winner are as varied as the characters of mankind in genera I think, however, that all good scientists have to be alert Also they all put in an awful lot of hard work. The try 100 times; maybe the 101st time they get the grea thing. You never read about the hundred times the went up the blind alley."

We asked him how he had arrived at the idea of th three-level maser. "Actually it was a fairly typical example of combining knowledge gathered in differen corners of science and putting them together to make an interesting combination," he told us. "I had neve thought about masers up to that time and we had n program here in that field of research. We just did research on microwave and general spectroscopy. Then heard a colloquium talk about masers by Professo Strandberg of M.I.T. that started me thinking. You might say it drew my attention to masers and how important they would be. Pretty soon I came up with a idea that later proved to work out very well. It took me a couple of weeks and it was the first time I ever forgo my wedding anniversary. My wife forgave me.

"That reminds me of a story," Professor Bloembergen continued. "As you know, most solid state masers now use a ruby crystal. In our first three-level maser, however, we used a crystal of potassium cobalticyanide into which was introduced an impurity of one half of one per cent of potassium chromicyanide. That is the active substance. The same impurity is present in ruby and gives its color to ruby. Anyway, in 1959, at a dinner at the annual meeting of the IRE, Professor Townes and I shared the Oliver Buckley prize for our work with the maser. Both Mrs. Townes and Mrs. Bloembergen were there and Mrs. Townes was wearing a ruby pendant in a gold chain around her neck. Professor Townes had made it for her in commemoration of the ruby maser and he had made the gold frame himself. Well, after dinner my wife came to me and asked me, 'When are you going to make me a ruby?'

" 'My dear,' I told her, 'my maser works with cyanide.' "

"It was one of the most exciting periods in my life, though I have had a lot of fascinating moments. The interesting thing about the maser was that the intellectual effort that went into it was much less than the intellectual

(*Continued on page 34*)

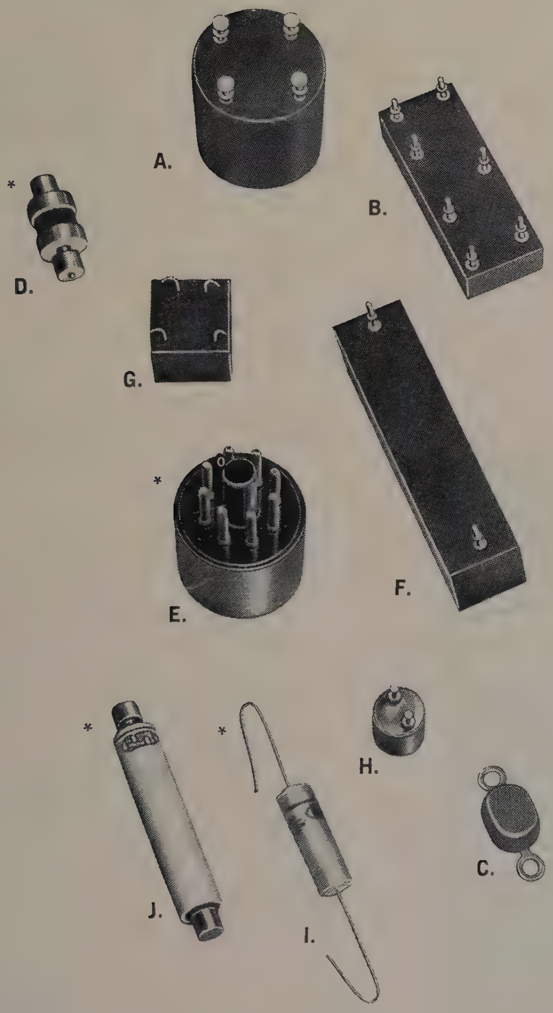
To 50,000 peak reverse volts per block to 6 amps DC per block

Solitron's new double diffused high voltage potted rectifier assemblies

Once again Solitron makes a valuable addition to solid state technology — a new line of double diffused high voltage potted rectifier assemblies rated up to **50,000 peak reverse volts per block and up to 6 amps DC per block!** Already in use at various military installations, the SDI Series Solidpaks are available in single phase (half wave, center tap or full wave) and three phase (half wave, full wave or star) . . . or in protective networks and tube replacements.

Solitron potted rectifier assemblies feature high reliability, high miniaturization (up to 6000 volts in ¾″ x ¾″ x 1″) and high surge ratings. Operating and storage temperature range is −65°C to 150°C. Life expectancy is unlimited. Regulation is excellent. **The SDI Series is the widest line of various configurations available for immediate delivery** — over 1,000 standard sizes to choose from. Mechanical and Electrical Engineering Service is free.

Write today for new 10-page technical catalog on the complete line of SDI Series Solidpaks!



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B. Double Full Wave Bridge
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G. Single Phase — Full Wave
H. Single Phase — Half Wave or Full Wave
I. Single Phase — Half Wave Ceramic Encapsulated
J. Single Phase — Half Wave Ferrule Type

*Available for JEDEC,"1N" Replacement.

Solitron
DEVICES, INC.
500 Livingston St. • Norwood, N. J.

BLOEMBERGEN

(*Continued from page 32*)

effort which has gone into many things before and since which were not as spectacular. . ."

Again, Dr. Bloembergen stressed the necessity for the scientist to be alert. As an example, he mentioned that, just the other day, he had applied an electric voltage in a magnetic resonance experiment. Nothing was more simple than applying an electric voltage to a crystal, and in fact, people had tried it before but not looked hard enough. "If you look really well," he remarked, "the effects of electric fields on magnetic resonance are there."

About his family, Dr. Bloembergen told us his wife was Dutch. She had been born and brought up in Indonesia and had spent the war interned in a Japanese prison camp. They had met in 1947, at a sailing party sponsored by the Science Club of the University of Leyden.

"Now that our children are old enough, I hope perhaps to buy a little sailboat. We have two girls of 10 and 6, and a boy of 8. The great trick was to give them Dutch names that would also sound well in English. My father's name sounds something like OKay in English. Obviously that would never do. Finally we settled on Antonia, Brink, and Juliana. We live in Lexington in a modern house with a wonderful view of the countryside. I became a citizen three years ago and we are happy to live in this country although we don't feel out of place in Europe. Science, of course, has a strong international flavor. Not long ago I attended a conference in Japan, speaking on my special topics of magnetic resonance a masers. Last year I attended scientific conferences i Toronto, London, and Pisa, Italy."

It seemed our interview was coming to an end. O side the open window, bells boomed resonantly fro somewhere on the Harvard campus. It was hard to co trast the summary, academic atmosphere with what D Bloembergen had told us of the grim wartime reali of Holland of his student days. We thought, too, the contribution he had made to microwave engineeri particularly we thought of the maser-equipped radiote scope of Harvard's Agassiz Station that was probi clouds of galactic dust to help us solve the problem the structure and evolution of the universe.

As if reading our thoughts, he remarked: "I like t atmosphere. I am not really a man to run a big organi tion or a machine. Mind you, if I can use it in my e periments I am glad to do so. But my research h usually been done with essentially modest equipment."

"Have you any forecast for the future of science?" asked him.

"In the next five years, I think we will make gre strides forward in chemistry and especially in biophysics where we barely stand on the threshold. As for myse I hope to take an active part in the fascinating develo ment of optics and optical masers, which will certai lead to new concepts in spectroscopy and perhaps in com munications in the next ten years. And let me stress t word exciting. I find my work even more exciting no than when I first arrived in this country."

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one source for all custom microwave components and sub-systems

—built from your prints, or designed to your specs —in record time . . . at production prices

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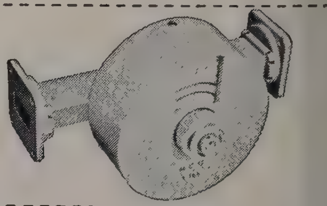
Typical MCS Custom Designs

—direct reading attenuators at X Band

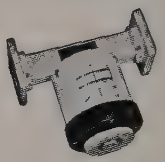
0-50 db

—only 6 inches long.



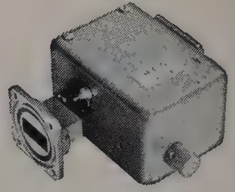
0- 10 db

Length, just 3 inches.



0-40 db

6-inch step attenuator
—from drafting board to customer in one week.



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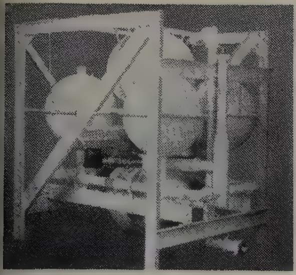
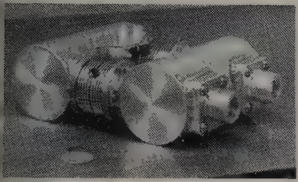
FOR DIRECTING, CONTROLLING, AND MEASURING RF ENERGY... DIELECTRIC'S PRODUCTS SATISFY EVERY PERFORMANCE NEED

FILTERS, DIPLEXERS & DUPLEXERS





. . . for all applications, waveguide or coaxial. In addition to its standard line of single- and double-tuned coaxial resonators which may be combined in many ways, *Dielectric* designs special networks for any power level, low to very high.

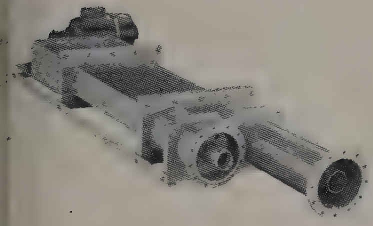
Illustrated is a network to isolate 20 kw commands to and 0.002 microvolt signals from a space vehicle, simultaneously. Built for Space Technology Laboratories, Inc., one of these giants is installed in the giant Jodrell Bank radio telescope. Also shown is a miniaturized balanced duplexer handling 10 kw average and weighing only five pounds.

For further information, specify proposed applications.

DIRECTIONAL COUPLERS

. . . provide for coupling external measuring and monitoring equipment to coaxial and waveguide r-f transmission systems. The range of coupling ratio is roughly 30 to 80 db, depending on model and frequencies. Directivity of standard models is ≥ 30 db, but ≥ 40 db can be supplied. Output source impedance is 50 ohms. Maximum power output is 4 watts for 3⅛" and larger coaxial models, 1 watt for smaller lines; 2 watts for 1½" x 3" and larger waveguide, 1 watt for smaller guides.

Request Bulletin No 61-5



PHASE SHIFTERS

. . . for any line size and impedance, and any degree of sophistication. Of particular interest is *Dielectric's* line of common-case, coaxial-line phase shifters which eliminate sliding joints in the outer conductor. Power handling capacity and life are both enhanced.

Phase shifters are available in manual and remote-control models, with or without provision for remote position indicating devices. All are characterized by low VSWR and wow, high power capability, and variable, linear phase shift.

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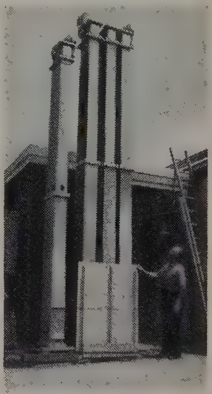

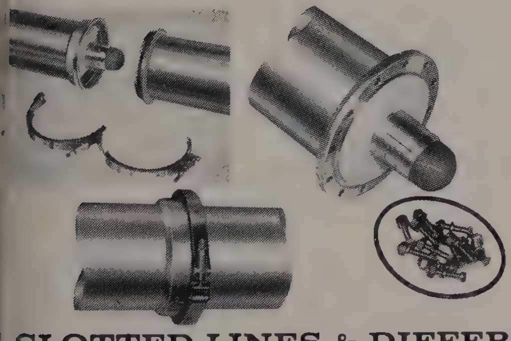

RIGID TRANSMISSION LINE

. . . in lengths up to 30 feet, copper or aluminum outer conductors. Standard sizes are ⅞, 1⅝, 3⅛, 6⅛, 9$\frac{3}{16}$ inches in all standard impedances from 25 to 200 ohms. Special sizes are available such as 9, 10, 12, 16 inches. Two basic styles: Quick-Clamp Type 40 featuring flange connections that swivel to any rotational angle, quick positive assembly by tightening only two bolts, and piloted flanges eliminating centering rings; or when specifications stipulate, the EIA (RETMA) Type 70 bolted-flange lines offering the same electrical characteristics.

Request Catalog No. 61-4

SLOTTED LINES & DIFFERENTIAL PROBES

. . . for measuring VSWR to 1.002 accuracy, the first and only major breakthrough in slotted-line measurement techniques. Improves resolution up to ten times that obtained with E-field probes. Available in 3⅛", 6⅛", and 9$\frac{3}{16}$" 50-ohm line sizes, other sizes and impedance on special order. Adapters and reducers to other line sizes can be supplied.

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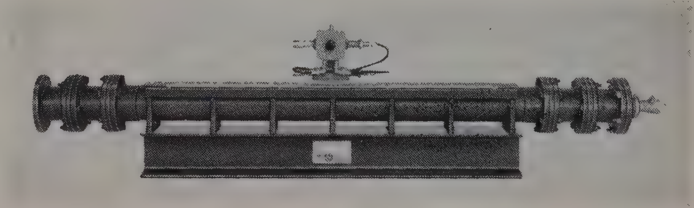

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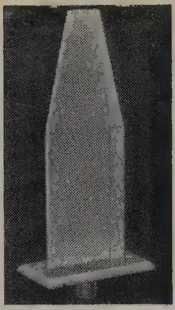
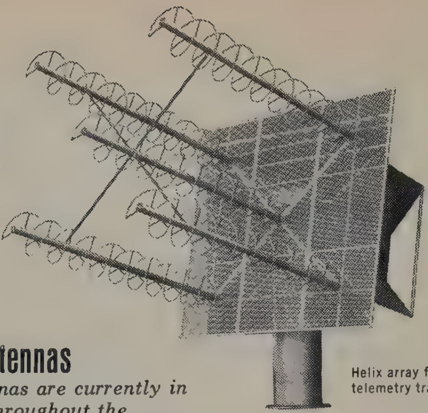


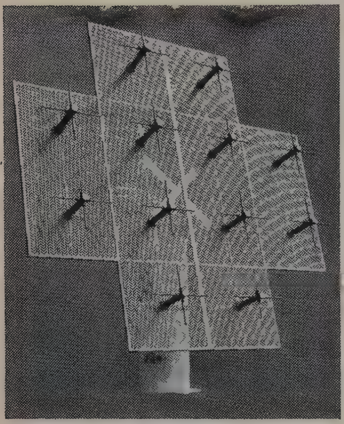
Airborne antennas
r communication, beacons
and radar augmentation



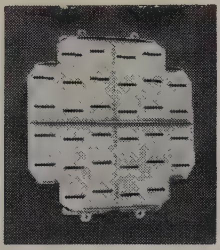
Helix array for
telemetry tracking systems

Antennas

Rantec tracking antennas are currently in operation at missile ranges throughout the free world. In addition, Rantec's airborne antennas are in quantity production for major missile and airframe programs.



Dipole array for
telemetry tracking systems

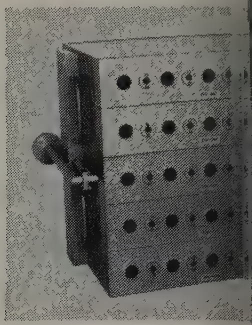


Two-dimensional "flat plate"
slot array for missile tracking and
guidance — monopulse or electronically
conical scan applications

3-channel, high isolation,
low insertion loss multiplexer

Telemetry Antenna Multi

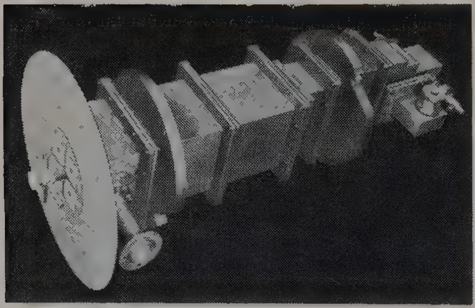
*Rantec multiplexers are used on a la
number of missile and space programs,
Mercury, Titan, Polaris, Discover
Midas, Nike Zeus, Nik
Subroc, Samos, X-17, Centau*



5-channel, high isolation,
low insertion loss multiplexer – 22

rantechnology

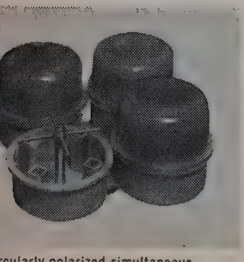
Over the years, a company normally becomes "pegged" into one or two specific categories of interest. Rantec has variously been described as "those people who make antennas" or "they're in ferrites." We would like to take this opportunity of outlining Rantec's broad level of design, development and production capability.



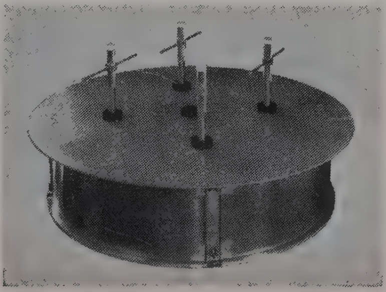
S-Band monopulse tracking feed,
integral L-band monitoring dipole

Antenna Feed Systems

Rantec feed assemblies are used on parabolic tracking and acquisition antennas ranging in size from 10 to 85 feet.

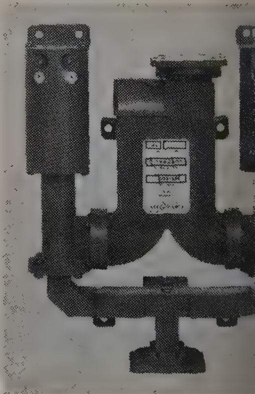


rcularly polarized simultaneous
bing feed — 890 Mc and 960 Mc

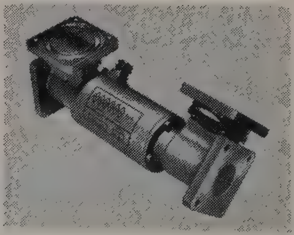


400 Mc remotely controlled
rotatable linearly polarized tracking
feed — hybrid assembly — drive

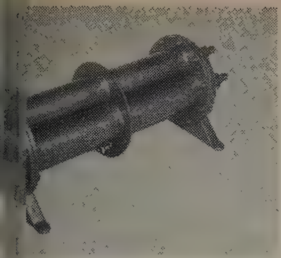
X-band single
sideband modulator



X-band
high speed switch

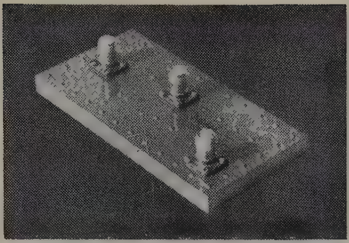


X_s-band
amplitude modulator

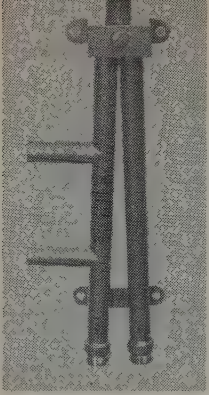


Airborne
nel multiplexer

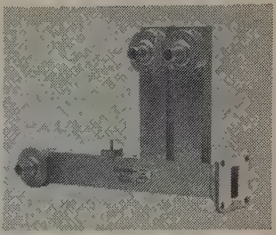
Strip line diplexing filter,
L-band and S-band



2300 Mc and 2900 Mc



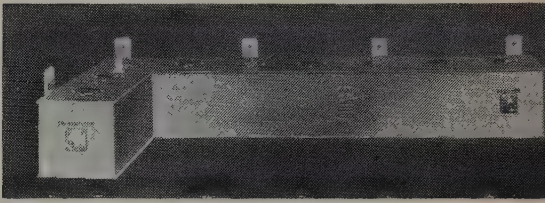
X-band
multiplexing filter



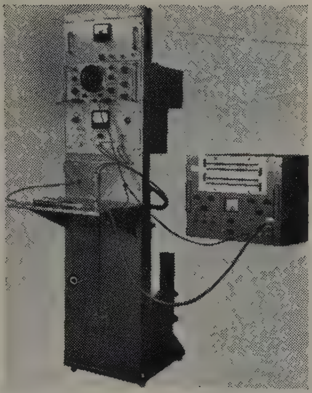
Filters

In addition to the units shown, Rantec has developed many othe filters for special applications. An impressive staff of engineers is available to handle complicated "state-of-the-art" problems.

890 Mc-960 Mc high power,
diplexing filter



Precision microwave phase
measurement system with
automatic frequency swept display



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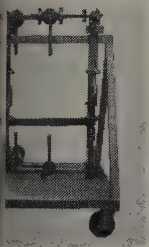
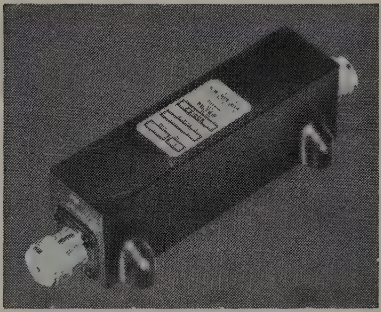
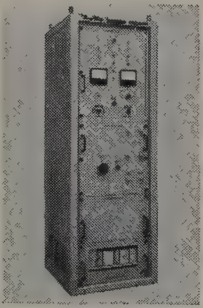




Band pass filter, 15 watt
CW unpressurized, 2200-2300 Mc

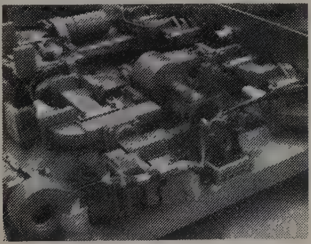


C-band doppler simulator,
using ferrite single sideband modulator

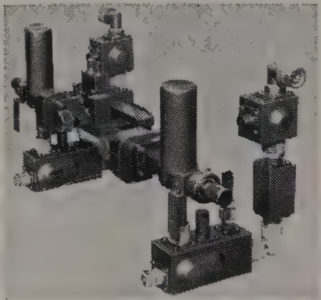
Special Test Equipment and R-F Sub-Systems

m the number of essential microwave components ıvailable in Rantec's standard line, considerable xibility exists for designing special test equipment, simulators and radar sub-systems.

Radar
sub-system, X-band

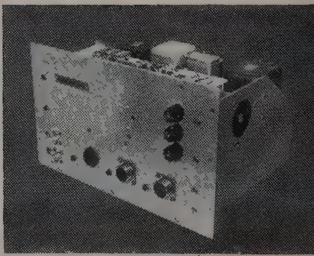


adband,



Dual channel C-Band
parametric amplifier system

Stabilized parametric
amplifier power supply



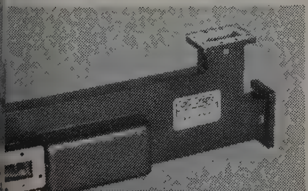
20% bandwidth S-band
Y-junction circulator

Parametric Amplifiers

Rantec's line of broadband, low insertion loss, ferrite devices and filters assure optimum performance of complete parametric amplifier systems. A variety of stable, low noise parametric amplifiers is available.

ite Devices

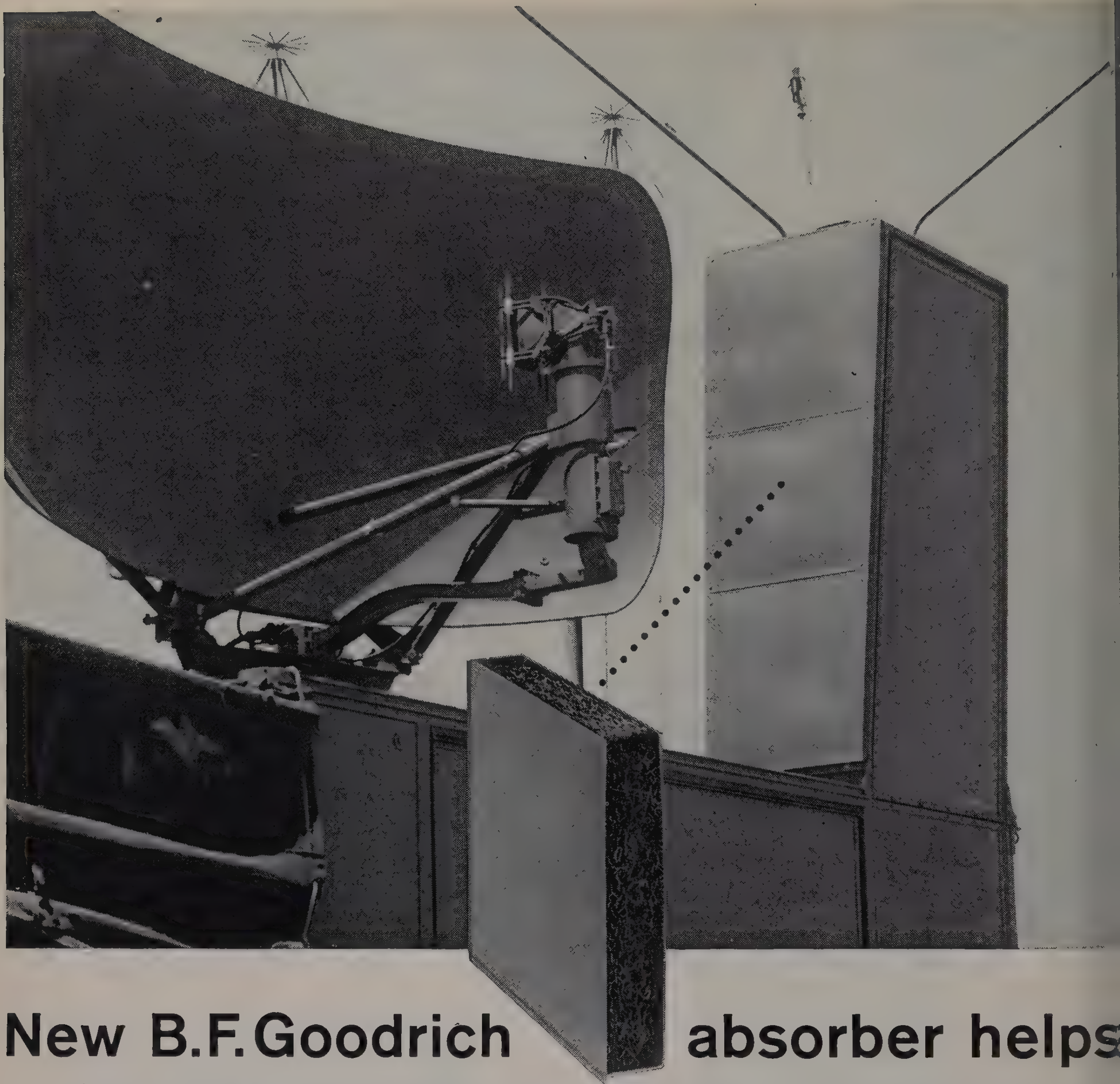
riety of advanced ferrite devices s available in frequency ranges below L-band through K-band.



These products are "typical" of Rantec's know-how, but represent only a part of the total picture. Write or call Rantec for complete product information in any of the above categories.

rantec

RANTEC CORPORATION
CALABASAS, CALIFORNIA



New B.F.Goodrich absorber helps increase radar coverage by 600%

All-weather panels eliminate radar-distorting reflections on jet aircraft guidance systems

THIS aircraft control guidance equipment is one of 183 in the U.S. Air Force network recently up-dated by Gilfillan Co., Los Angeles. The result? 600% more airspace now radar-controlled for safer guidance of USAF jets.

To cope with the more powerful equipment, B.F. Goodrich developed a new broadband absorbing panel to isolate the metal tower from the scanning of the antenna, thereby eliminating radar-distorting reflections.

As shown in the cutaway section, a 2″ thickness of BFG's hair-type absorber is permanently sealed into a fiberglass-covered aluminum panel. The assembly i completely waterproof, capable of long service in a weather conditions from the arctic to the equator. Th light, strong, easy-to-install panels can be made in variety of thicknesses to cover different frequency ranges

In addition to use on guidance equipment, these BF Type EN (enclosed) panels also improve the performanc of communication and navigation systems, and increas the accuracy of outdoor testing ranges.

Send for our new booklet on microwave absorbers Just write *B.F.Goodrich Sponge Products, 130 Derby Plac Shelton, Conn. Foreign inquiry, except from Canada, should b addressed to Microwave International Corporation, 36 We 44th St., New York 36, New York.*

MICROWAVE ABSORBERS BY B.F.Goodrich

Circle Reader Service Card 25

(*Continued from page 20*)

NOLAND APPOINTED SECTION NGINEERING HEAD AT SPERRY

ohn R. Whitford, manager of the Sper- Electronic Tube Division, Gainesville, , has announced ep-up in the re- rch and develop- nt program of kward wave os- ators with the pointment of aes Noland as gineering section d.

Noland, who has horized many icles in the mi- wave field, will direct the development advanced types of backward wave os- lators. Efforts of his group in this a will parallel the manufacturing and rketing of a new line of Sperry tubes instrumentation and military markets. also holds a patent on signal trans- ssion elements and their manufacture.

Prior to his association with Sperry ctronic Tube Division, Noland was ployed by General Telephone and Elec- nic Laboratories. While there he did velopment work on backward wave os- lators, oscillators, amplifiers, and crys- detectors. In addition he has worked a graduate assistant at Purdue and has tured at Hofstra College.

Noland received BS and MS degrees in ysics at Purdue University in 1947 and 50. He is a member of Sigma Xi, gma Pi Sigma, IRE, APS and RESA.

— *m w j* —

RAYTHEON AWARDED $37.3 MILLION "HAWK" CONTRACT

Contracts totaling $37.3 million have een awarded to Raytheon Company by e Boston Ordnance District for further roduction of the Hawk surface-to-air issile system.

Of the total, $22 million is for missiles, 13 million for high power illuminator dars and associated ground support quipment with the remaining $2.3 million r field maintenance equipment.

Work will be performed at Raytheon's ero/Weapons Division plants at Ando- er, Lowell and Waltham, Mass., Bristol, enn. and Oxnard, Cal., and the Equip- ent Division's North Dighton, Mass., fa- ility.

Hawk is operational with Army forces ere and abroad and has been adopted for se by the Marine Corps as a highly mo- ile field weapon. Five NATO nations ave selected this missile system for pro- uction in Europe as a mutual air defense eapon.

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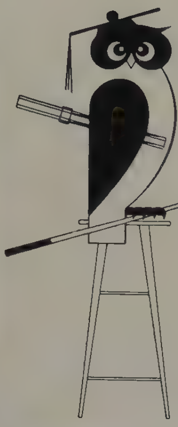
(*Continued on page 41*)



HOW TO COUPLE FLAT OVER FULL OCTAVE BANDS

SAGE
NATICK, MASS.
Laboratories, Inc.
MOD.
SER.

Directivity — 18 db min.
Connectors — Female Type N

Sage Laboratories TEMLINE Directional Couplers are the result of several months of development and a few strokes of good fortune. The series includes six models which cover the 60 to 4000 mc frequency range in octave band steps. Each model provides flat coupling over its full octave band and is operable well above and below its specified band, with some sacrifice in coupling. All models feature high average power, uniformly high directivity, low VSWR at all terminals, and two coats of paint.

The TEMLINE mechanical configuration is well suited to compact systems requirements. Specific mounting provisions and alternative connectors are available on special order.

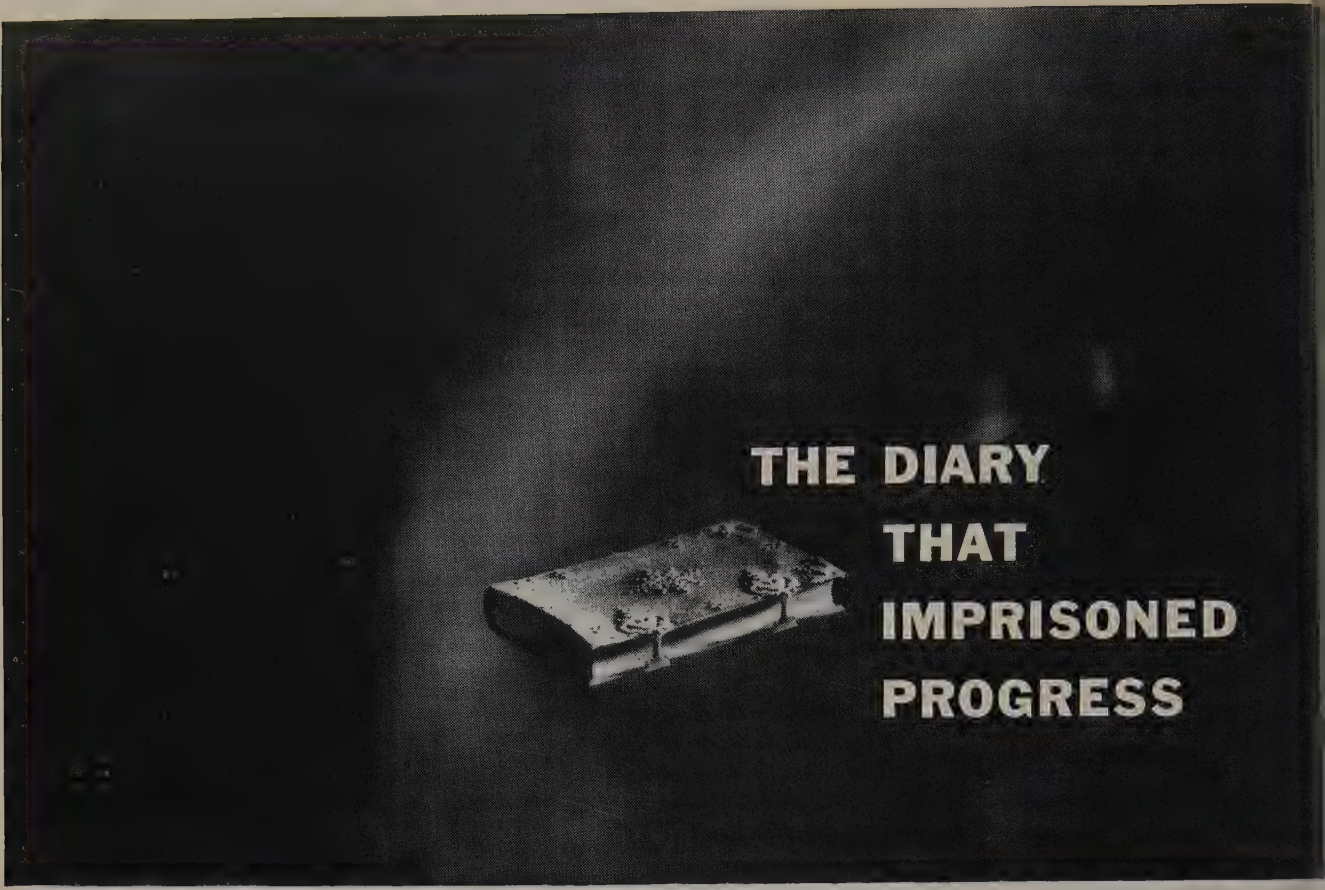
Prices subject to change without notice

MODEL NUMBER	FREQUENCY RANGE	COUPLING	MAX. VSWR	BODY DIMENSIONS H x W x L	WEIGHT	PRICE
-3 748-6 -10	60-125 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.20	⅞" x 1⅜" x 22¹¹⁄₁₆"	6 LB 3 OZ	$235.00
-3 749-6 -10	125-250 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.20	⅞" x 1⅜" x 11¹¹⁄₁₆"	3 LB 5 OZ.	$185.00
-3 750-6 -10	250-500 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.20	⅞" x 1⅜" x 6⁵⁄₁₆"	1 LB 15 OZ	$185.00
-3 751-6 -10	500-1000 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.25	⅞" x 1⅜" x 3¹⁵⁄₃₂"	1 LB 3 OZ	$185.00
-3 752-6 -10	1000-2000 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.25	⅞" x 1⅜" x 2³⁄₃₂"	14 OZ	$185.00
-3 753-6 -10	2000-4000 mc	3 db ± 0.5 db 6 db ± 0.75 db 10 db ± 1.0 db	1.25	⅞" x 1⅜" x 1½"	9 OZ	$185.00

Inquiries concerning special designs are invited.

SAGE LABORATORIES, INC.
3 HURON DRIVE • EAST NATICK INDUSTRIAL PARK • NATICK, MASSACHUSETTS •

Circle Reader Service Card 26



Nearly two centuries ago, Karl Gauss, "Prince of Mathematicians," kept a diary which was destined to become one of the most significant documents in the history of mathematics.

In his diary Gauss jotted down the results of elaborate calculations that had led him to fundamental discoveries in mathematics. But he never published these discoveries, and many of them remained undisclosed during his lifetime.

It wasn't until almost 50 years after Gauss's death that his diary was found and published. Much time and talent, meanwhile, had been spent in duplicating Gauss's efforts. Mathematical progress had been needlessly slowed.

In contrast, today's scientists and engineers are alert to the importance of sharing their findings through publication. In fact, the number of definitive papers published in a scientific or technological field has become a sure sign of the creative effort in that field.

Bell Laboratories scientists and engineers publish more than 800 papers a year, reporting new observations and new thinking in the arts and sciences that serve communications. They have also authored more than 50 technical books, many of which have become standard works of reference. The steady stream of new information that comes out of Bell Laboratories again reflects the scope and depth of the creativity that works to improve Bell System communications.

BELL TELEPHONE LABORATORIES

World center of communications research and development

(Continued from page 39)

YLVANIA APPOINTS DR. FAFLICK TO SENIOR STAFF

The appointment of Dr. Carl E. Faflick s senior staff specialist-systems for Sylvania Electronic Systems, Waltham, Mass., a division of Sylvania Electric Products Inc., has been announced by Dr. Edwin G. Schneider, divisional vice-president - Research and Engineering.

Dr. Faflick previously was manaer of the microwave and antenna laboraory at Sylvania's Waltham Laboratories. n his new capacity, Dr. Faflick will reiew the technical performance of the diision, improve the exchange of technical nformation, and plan and monitor a techical training program.

Dr. Faflick joined Sylvania's Boston Engineering Laboratory, which later was incorporated into the Waltham Laboratories, as an engineering specialist in 1953. He subsequently was appointed section head in the microwave section in 1954, manager of the antenna and microwave department in 1955, and manager, antenna and microwave laboratory in 1960.

Dr. Faflick received a bachelor's degree from Oberlin College, Ohio, in 1943. Following graduation, he served with the U. S. Army Signal Corps for three years. He received a PhD degree in applied science from Harvard in 1953.

Dr. Faflick is a member of Sigma Xi, honorary scientific fraternity, and a former chairman of the Boston chapter of the Institute of Radio Engineers' professional group on microwave theory. He is currently vice chairman of the Boston Section of IRE.

—mwj—

PRD ACQUIRES HELF AS PROJECT MANAGER

William Helf, Jr., has joined PRD Electronics, Inc., subsidiary of Harris-Intertype Corp., Brooklyn, N. Y., according to Henry H. Michaels, Jr., president of PRD. Helf will serve as project manager for systems analysis in the Weapons Systems Division.

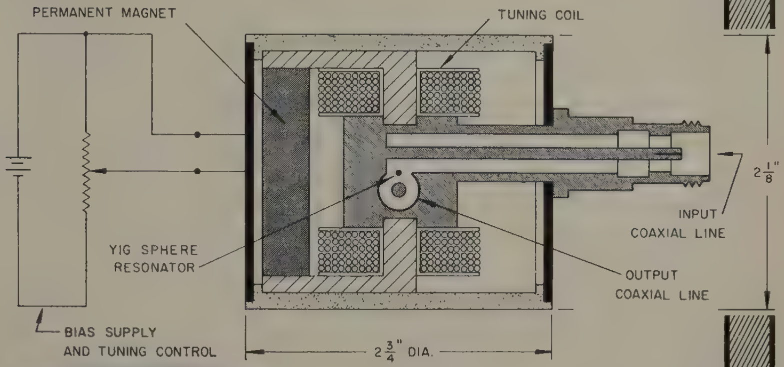
Helf comes from General Dynamics Electronics, where he was a principal engineer in the Electronics Engineering Dept. In this capacity, he was project engineer in charge of a program for determining detail requirements for a depot oriented versatile automatic test system.

Helf received his BEE degree from the Pennsylvania State University and the MEE degree from the Polytechnic Institute of Brooklyn. He is a Senior Member of the IRE.

—mwj—

(Continued on page 42)

Electronically-Tuned Filter



JOHNSON COMPANY
TYPE WJ-501
SER. NO. 00

IN MICROWAVE SYSTEM applications it is desirable to have a relatively narrow instantaneous rf bandwidth which can be tuned quickly and easily over a wide band. Watkins-Johnson Company has developed the first microwave pre-selector filter which can be electronically tuned over a wide range of frequencies with relatively low insertion loss in band-pass and band-reject applications. The WJ-501 offers solutions to rapid signal sorting and selection requirements in S-band. Other developments are current in C- and X-band and the millimeter-wave region.

Typical Performance Characteristics

Frequency (Mc)	2000-4000
Insertion Loss	2 db-0.5 db
Bandwidth (3 db)	15-25 Mc
Off Resonance Isolation (db)	>40 db
DC Tuning Current (Max.)	400 ma
DC Tuning Voltage	8 v
Tuning Sensitivity	2.5 Mc/ma

Information in more detail available from representative in your area, or from Applications Engineering

WATKINS-JOHNSON COMPANY

3333 HILLVIEW AVENUE
STANFORD INDUSTRIAL PARK
PALO ALTO, CALIFORNIA

Circle Reader Service Card 27

Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

The Laboratory is seeking qualified specialists in:

RADIO PHYSICS and ASTRONOMY

NEW RADAR TECHNIQUES

SOLID STATE PHYSICS and METALLURGY

A more complete description
of the Laboratory's work will
be sent to you upon request.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

Industry News

(*Continued from page 41*)

DORSETT DEDICATES "SCIENCE SQUARE"

U. S. Senator Robert S. Kerr, chairm of the Senate Space Committee, was featured speaker at the recent dedicati of Science Square, center of newly panded Dorsett Electronics, Inc., in N man, Okla.

The dedication commemorated the op ing of three divisions in the Squ including the Electronic Laboratories D vision, which manufactures transistoriz space and missile telemetry equipment.

The newly acquired and expanded fac ities enlarged the Dorsett corporation 12 operating divisions in seven cities various parts of the country. The develo ment of the 11-year-old company has be directed by its founder and preside Loyd G. Dorsett.

Other divisions include the Americ Missile Products Division in Lawnda Cal., devoted to satellite and missile i strumentation, and the newly organiz Dorsett Princeton Research Division Princeton, New Jersey, which will be i volved in microwave and semiconduct application research.

Total Dorsett sales for 1961 are expec ed to reach $10-16 million. Projected sal for 1965 are estimated at $100 million.

— *m w j* —

ALTSHULER TO DIRECT RESEARCH AND DEVELOPMENT AT GABRIEL

Dr. Edward E. Altshuler has bee named director of Research and Develop ment for Gabri Electronics, it ha been announced b Robert F. Stewa general manager The Gabriel Com pany's Electroni Division, Milli Mass.

Mr. Stewart sa Dr. Altshuler responsible for th overall researc and development of new antenna products in addition to coordinating the Division' engineering activities.

A native of Boston, Dr. Altshuler ob tained a bachelors degree in physics fro Northeastern University, Boston, in 195 and a masters degree in physics from Tuft University, Medford, Mass., the followin year. He studied part time at Harvar University from 1954 to 1957, then bega attending full time until he obtained PhD degree in applied physics in 1960.

From 1954 to 1957 he was employed b Sylvania Electric Products, Inc., Waltha Mass. Until recently he had been associa ed with Electromagnetic Radiation Labo atories, Bedford, Mass. He is a membe of IRE, Sigma Xi and Pi Sigma.

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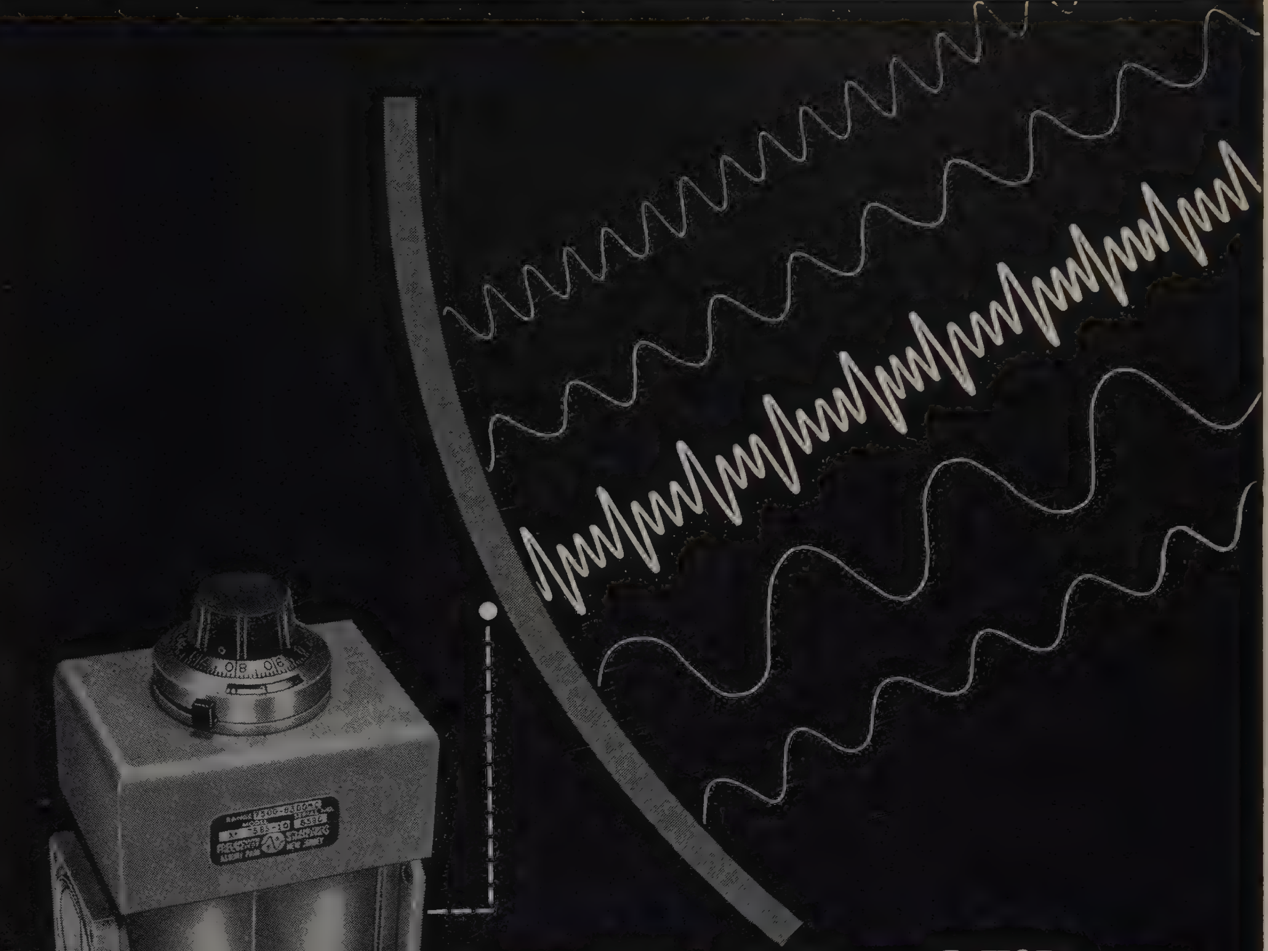
(*Continued on page 44*)



Tunable-X Band Filters

MAXIMUM REJECTION ● LOW INSERTION LOSS
● DELIVERY FROM STOCK

Now, Frequency Engineering Laboratories, world leader in microwave filter technology, introduces a new series of precision tunable bandpass filters covering the range of 7 to 12.5 Gc — assembled and delivered from stock in two weeks or less!

These filters feature a bandwidth of 8 to 12 mc at 3 db and 60 mc at 30 db with 2 db insertion loss . . . VSWR of 1.5 max. at F_0 . . . temperature stability of 3 cps/Mcs/°C maximum drift over wide temperature range . . . two direct-coupled TE_{111} mode cylindrical cavities with single tuning control . . . counterdial and calibration chart or slotted shaft adjustment. Price: $398.00 each (less quantity discount).

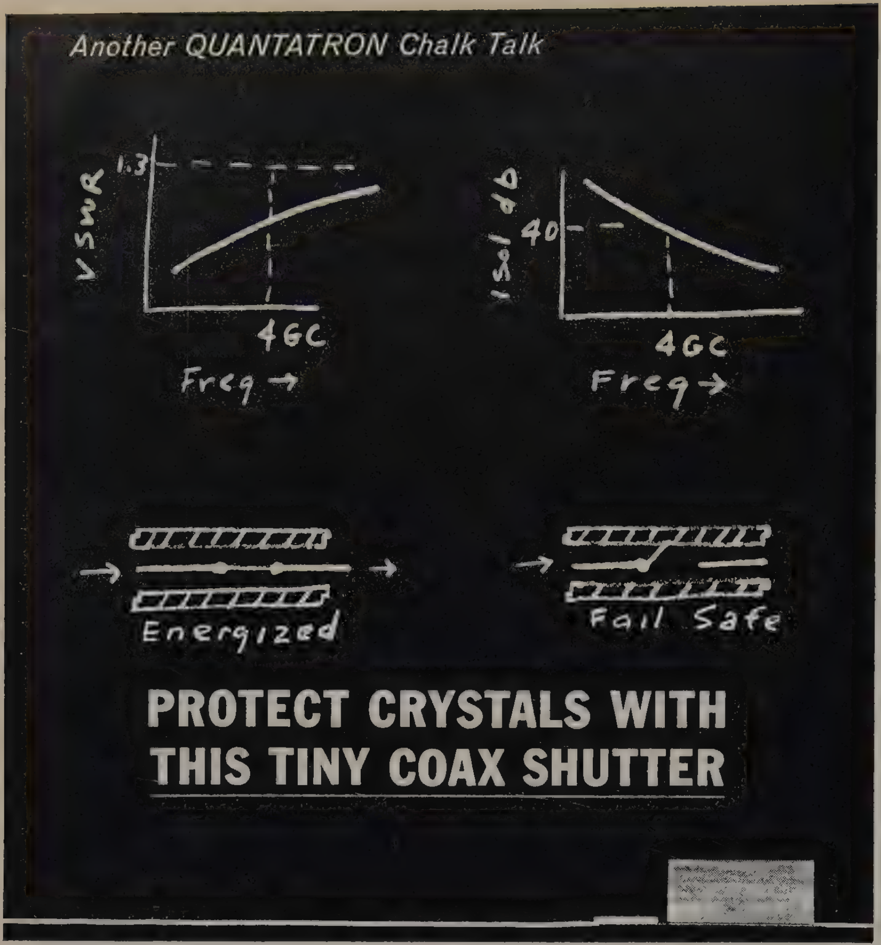
Frequency Engineering Laboratories' 14 years of experience in the development and production of high performance microwave filters is available to you without obligation. Look into our capabilities for special preselectors with balanced mixer as well as low bandpass and band rejection filters for both high and low power applications. Write for Bulletin P-26102 or send specific bandwidth and other requirements to Department KF.

FREQUENCY ENGINEERING
LABORATORIES . . . . . . formerly FREQUENCY STANDARDS
A DIVISION OF HARVARD INDUSTRIES, INC.
BOX 504 · ASBURY PARK, N. J. · PROSPECT 4-0500

Center for new ideas in microwave technology — Discriminators, Antenna Couplers, Diplexers, Wavemeters, Reference Cavities, Signal Sources, Directional Couplers, Antennas, Cavities

Circle Reader Service Card 28

Another QUANTATRON Chalk Talk



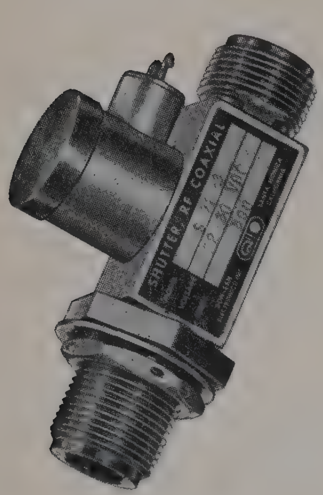
PROTECT CRYSTALS WITH THIS TINY COAX SHUTTER

Add or remove 40 db of isolation with a wink of this microwave eye—operates in 6 milliseconds. Small and rugged, the DON-LAN Model S-70 Coaxial RF Shutter is designed to function reliably in extreme environments of shock, vibration and temperature. This remotely-operated device protects crystal diode and other receiver components against burnout or damage.

These miniature S-70 shutters are but one of the unique DON-LAN family of microwave products. Write for details. Also ask about switches, tuners, attenuators and other coaxial and waveguide system components.

Consult our engineering staff on your microwave problems.

ACTUAL SIZE



Don-Lan Electronics Inc.
a subsidiary of
Quantatron, Inc.
2520 Colorado Avenue
Santa Monica, California
EXbrook 3-0758

Employment opportunities for qualified microwave engineers

Industry News

(*Continued from page 42*)

LFE ELECTRONICS AWARDED MULTI-MILLION DOLLAR AIR FORCE CONTRACT

LFE Electronics, a division of Labo tory For Electronics, Inc., Boston, Mas has been awarded a letter contract expe ed to total in excess of $20 million wh definitized. Initial expenditures of $ million have been authorized on the U. Air Force contract for production of LE Electronics' AN/APN-131 self-containe airborne Doppler navigation systems.

As an integral part of the F-10 "Thunderchief", the AN/APN-131 pr vides the Mach 2 fighter-bomber with pr cise, all-weather navigation without ref ence to ground-based installations. By s doing, it enhances the tactical capabili of the Air Force to react quickly and s lectively on a global basis.

The current award to LFE Electronic part of the original F-105D procuremen program scheduled through 1964, is th sixth multi-million dollar prime contra for production of this equipment receive by the Systems Division in the past thre years. Production on contracts received t date is scheduled through March, 196 with shipments to coincide with deliver of aircraft already under contract to Re public Aviation Corp.

The definitized contract will brin LFE's backlog to approximately $39 mi lion, compared with a backlog of $23. million at the end of April, 1961.

— *mwj* —

APPLEMAN JOINS MSI AS CHIEF ENGINEER

Sidney Appleman has been appointe as Chief Engineer of MSI Electronics, Inc a wholly owne subsidiary of Microwave Semiconductor & Instruments Inc., i Richmond Hil Queens, New York

In announcin the appointmen Mr. Albert Lederman, president o MSI, said that M Appleman woul be responsible for the design, developmen and production of a proprietary line o traveling wave tube amplifiers and backward wave oscillator sweep generators In addition to this Mr. Appleman will b in charge of the company's efforts wit respect to research and development o advanced electronic warfare systems fo agencies for the Department of Defense

Mr. Appleman was previously wit Loral Electronics Corp., as a staff engineer specializing in the design of microwave systems and components. He wa responsible for the development of certai aspects of the ALQ-53 Receiver.

— *mwj* —

LUNDBERG JOINS S-F-D AS SENIOR MECHANICAL ENGINEER

Wayne R. Lundberg has joined S-F-D Laboratories, Union, N. J., as a senior mechanical engineer. He will be engaged primarily in the development of high power magnetron tubes, particularly those for high resolution detection radars.

S-F-D laboratories, a subsidiary of Varian Associates, is engaged in research and development of microwave tubes and other electronic devices. These devices are essential components that generate, amplify and detect microwaves in radar and in communications systems.

Mr. Lundberg was formerly associated with the Western Electric Company, Laureldale, Pa., as department chief of the Product Engineering Department. His work there included the development of advanced techniques related to the production refinement of advanced magnetrons.

He received a degree in electrical engineering from Iowa State University in 1956 and is a member of the Institute of Radio Engineers.

— *m w j* —

1962 PGMTT NATIONAL SYMPOSIUM CALLS FOR PAPERS

The 1962 PGMTT National Symposium will be held on May 22-24, at the Boulder Laboratories of the National Bureau of Standards in Boulder, Colorado.

A call for papers concerned with research, development, and applications in all areas of the microwave field is hereby issued. The Technical Program Committee for the Symposium will be particularly interested in original, creative papers dealing with topics of relatively wide and current interest.

Prospective authors are asked to submit both 50-100 word abstracts and 500-1000 word summaries accompanied by up to six figures suitable for reproduction in a Symposium Digest to be distributed to all registrants.

This material should be sent to:

R. W. Beatty, Chairman
Technical Program Commitee
1962 PGMTT National Symposium
National Bureau of Standards
Boulder, Colorado

Deadline for receipt of this material is 18 December, 1961. Notifications of acceptance or rejection will be sent out by 15 January, 1962. Revisions of summaries of accepted papers for the Digest will be accepted until 15 February, 1962. Publication of a summary in the Digest will not prejudice later consideration of the complete paper for publication by the IRE Transactions on Microwave Theory and Techniques.

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(*Continued on page 46*)

NEW Stewart permanent-magnet-focused BWOs

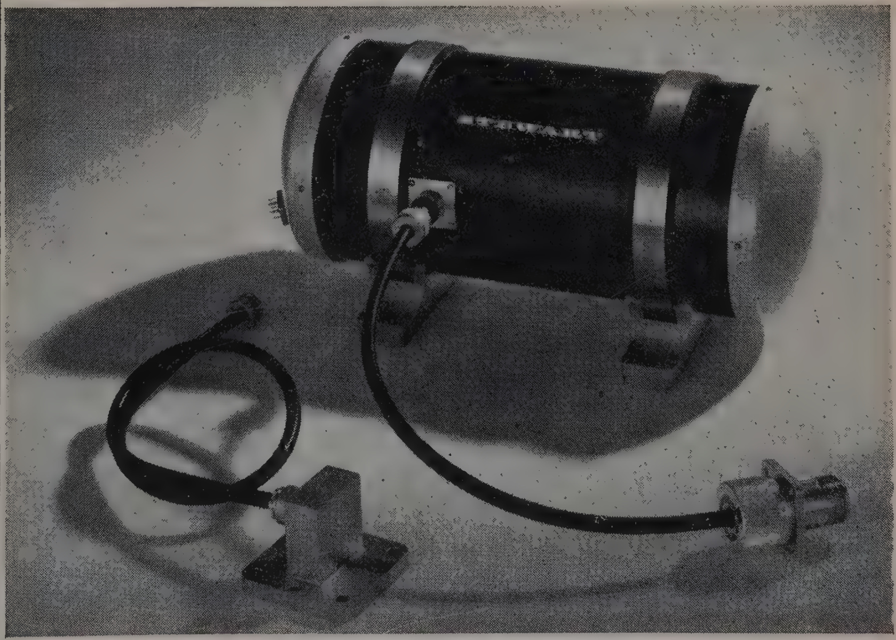
From the industry's only manufacturer devoted predominantly to backward-wave oscillator technology, the tubes described below represent a major advance in design. Focused by integral permanent magnets, they eliminate the need for solenoids and their associated power supplies, and provide a significant saving in space. They do not require forced-air cooling.

The Stewart trade-mark on these new X-band tubes carries with it the same implications of sustained high levels of performance and stability expected of all Stewart tubes. Typical life of Stewart BWOs is 5000 operating hours without loss of performance.

Inquiries are invited on the tube types described here, and on other standard and special BWOs in frequency ranges from 1 through 40 Gc. PM focused tubes for other bands are in process of development.

TYPE	SE 201	SE 202
Frequency range and minimum power output	7.0-12.4 Gc, 10 mw 8.2-12.4 Gc, 20 mw	8.2-12.4 Gc, 10 mw
Maximum tuning voltage	2000 v	1500 v
Cathode current	4-7 ma	4-7 ma
Grid cutoff voltage	—15 v	—15 v
Power Variation, Max. p-p	6 db	3 db
Weight, Max.	11 lbs.	11 lbs.

STEWART
STEWART ENGINEERING COMPANY
Santa Cruz 2, California



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PRECISION HERE

MEANS ACCURACY HERE

Careful welding of massive structures to precise tolerances is just one of the skills Blaw-Knox contributes to provide accurate operation of some of the world's largest radar and tracking antennas and radio telescopes.

Only the skill that comes from many years' experience provides the master craftsman touch that enables Blaw-Knox antennas to be built . . . to the close surface tolerances and to the fine pointing accuracies required by our customers. And Blaw-Knox engineering assures the right design to make the best use of those skills and Blaw-Knox unique shop facilities.

Blaw-Knox designs and builds to close tolerances, with minimum deflections, at reasonable cost—fabricates in steel, special alloys and aluminum—designs to your needs, or builds to your specifications. Complete research, engineering, testing and fabricating facilities are at your disposal. Write or phone today for immediate attention. Blaw-Knox Company, Pittsburgh 38, Pennsylvania. Phone, STerling 1-2700.

BLAW-KNOX
ANTENNAS

BLAW-KNOX

Blaw-Knox designs and manufactures for America's growth industries: METALS: Rolling Mills • Steel Processing Lines • Rolls • Castings • Open Hearth Specialties • PROCESSING: Process Design, Engineering and Plant Construction Services • Process Equipment and Pressure Piping • CONSTRUCTION: Concrete and Bituminous Paving Machines • Concrete Batching Plants and Forms Gratings • AEROSPACE: Fixed and Steerable Antennas • Radio Telescopes Towers and Special Structures • POWER: Power Plant Specialties and Valves

Industry News

(*Continued from page 45*)

MARGOSIAN REJOINS POLARAD

John W. Margosian is rejoining Po arad Electronics Corp., Long Island Cit N. Y., after an a sence of a year, assume the positi of technical assi ant to Mr. Frank Skwarek, vice-pre dent in charge Polarad's Defen Products Divisio

Mr. Margosian previous affiliati with Polarad w as Electronic S tems manager engaged in the developme of special purpose miniaturized receivin data storage systems for the Air Force.

Prior to his return to Polarad Mr. Ma gosian was vice president and director Engineering of Microwave Dynamics Co poration. He holds degrees from CCN and the Polytechnic Institute of Brookly where he later served on the facult Since resignation from his education pursuits in 1950, Mr. Margosian has bee actively engaged in the electronics indu try in research and management position

He is a Senior Member of the Institut of Radio Engineers, and is a member the American Institute of Electrical En gineers, the Institute of Aeronautic Sciences, and Sigma Xi Honorary Frate nity.

— *mwj* —

AVIEN APPOINTS YAGERMAN AS SUB-SYSTEM SALES MANAGER

Appointment of Bernhard Yagerman the newly created post of Sub-System Sale Manager, Antenna Division, Avien, Inc., Woodside, N. Y., has been announced by Richard D. Bogner, Manager of the Division.

Mr. Yagerman will be responsible for the overall marketing activities of the Antenna Division's sub-system sales program, accordin to Mr. Bogner. Avien's antenna sub-sys tems, Mr. Bogner noted, have found a increasing application in the general fiel of extremely broad-band, unambiguou acquisition, track and frequency surveil lance.

Prior to joining Avien, Mr. Yagerma was Sales Manager, Electronics Division Telechrome Manufacturing Company Amityville, Long Island. Mr. Yagerman background includes ten years as a sale executive in the fields of communicatio telemetry, data processing, range instru mentation and weapons systems.

— *mwj* —

(*Continued on page 48*)

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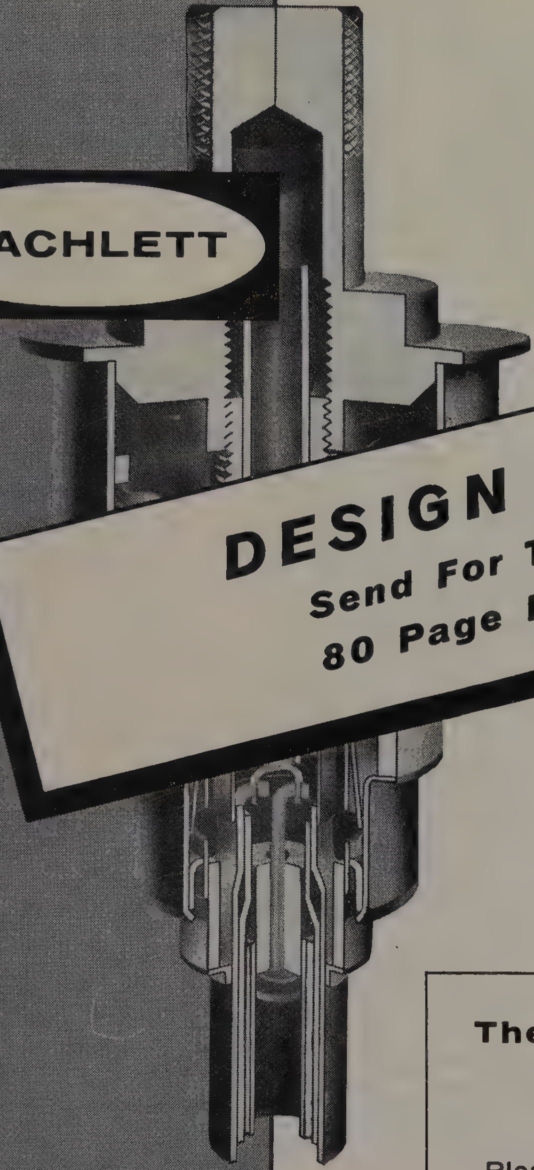

MACHLETT

DESIGN INFORMATION

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80 Page Machlett UHF Brochure

The Machlett Laboratories, Inc.
Division of Raytheon
Springdale, Connecticut

Please send me the UHF Planar
Triode Brochure.

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Name____________________________

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____

UHF PLANAR TRIODES

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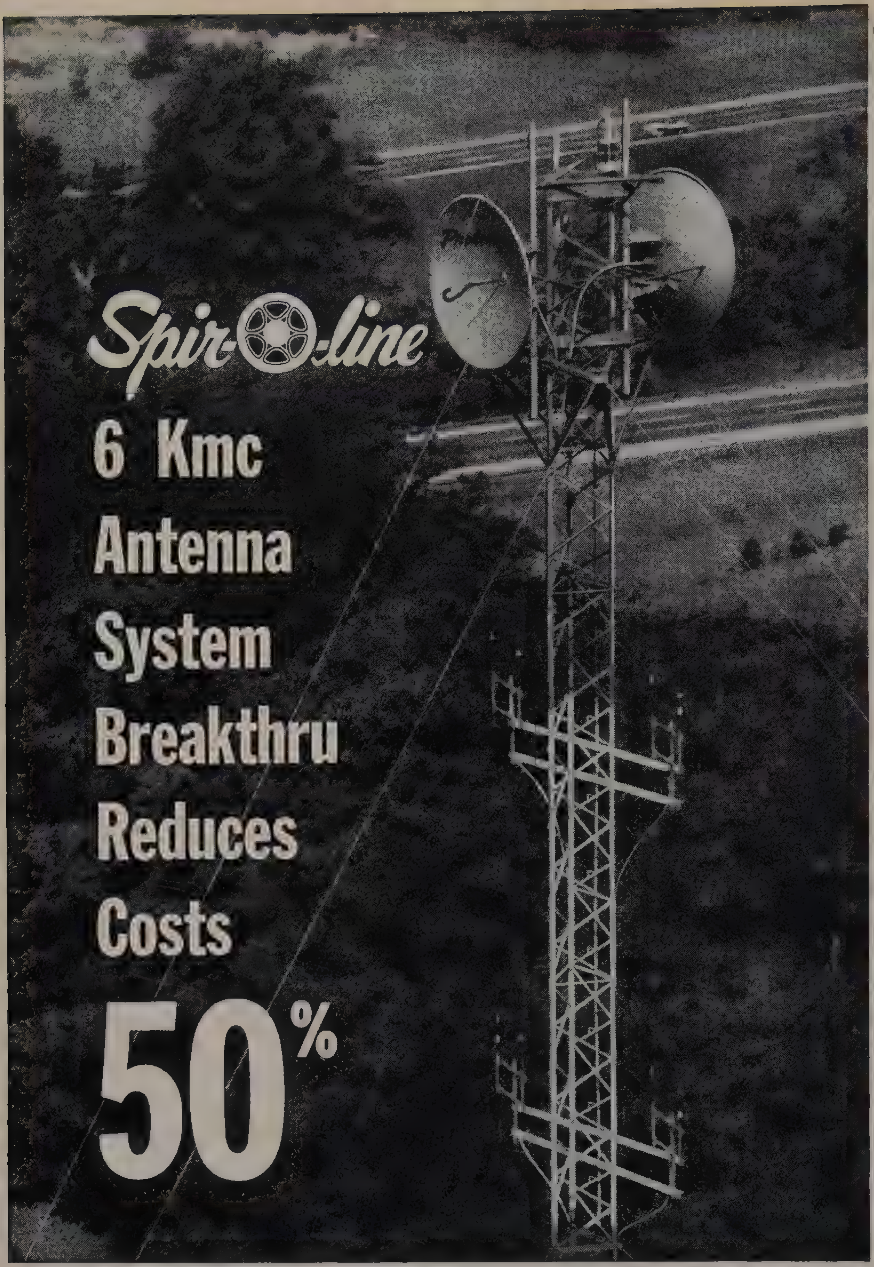

The nation's most modern 6Kmc microwave system is now in operation for the 173-mile New Jersey Garden State Parkway, providing reliable and efficient communications service with Prodelin's Parabolic Antenna System — a unique new concept in the art.

Utilizing low-loss Spir-O-line coaxial cable, this Prodelin 6Kmc Antenna System eliminates passive reflectors and rigid wave guides, reduces installation labor, lowers initial equipment costs, simplifies handling, and reduces engineering contact and planning time.

Systems engineers should not overlook the advantages of this latest Prodelin achievement.

■ TELEVISION ■ TELEMETRY ■ MOBILE ■ MICROWAVE ■ MARINE ■

MANUFACTURERS OF THE WORLD'S FINEST
Prodelin Inc ®
ANTENNAS AND TRANSMISSION LINES

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U.S. PATENT NO. 2,998,472

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Industry News

(*Continued from page 46*)

PIFER PROMOTED AT ANTLAB

Morris M. Robison president of A lab, Inc., Worthington, Ohio, has a nounced the promotion of Peter M. Pif from chief of Electronics Department chief engineer for the company.

Trent E. Davis, a design engineer f the firm, was named to the post vaca by Pifer.

Antlab, founded by Mr. Robison 1954, designs and manufactures miss tracking systems, antenna pedestals, mic wave receivers, and associated anten range instrumentation.

— *m w j* —

RILEY ASSIGNED SALES RESPONSIBILITY IN 15 EASTERN STATES

Vroman W. Riley has been assign sales responsibility in 15 Eastern stat for the Radio Corporation of America's Microwave Department, it has been announced by W. C. Byrne, Marketing Manager.

Mr. Riley, whose headquarters will be in Camden, N. J., succeeds R. J. Fichthorn who has been transferred to the Department's national accounts grou

Mr. Riley previously had been Midwe Sales Manager for Motorola Communic tions and Electronics for the past sev years. A native of Chicago, he graduat from Illinois Institute of Technology wi a bachelor's degree in electrical enginee ing, and is a Professional Engineer in t state of Illinois.

— *m w j* —

ASH ELECTED PRESIDENT OF LITTON INDUSTRIES

Roy L. Ash has been elected preside of Litton Industries, Inc., Beverly Hil Cal., Charles B. Thornton, chairman a chief executive officer of the company, h announced.

Mr. Ash has been successively vi president; vice president and treasure president of Litton Systems, Inc., the company's largest operating subsidiary, an executive vice president of Litton Indu tries.

He was associated with Mr. Thornt in the formation of the present Litton I dustries. Prior to that he had been wit Hughes Aircraft Co., and earlier, the Ba of America. During World War II, was an officer in the U. S. Air Force a signed to strategic analysis and control.

Mr. Ash was graduated as a Bak scholar from the Graduate School of Bus ness Administration of Harvard Unive sity.

— *m w j* —

(*Continued on page 50*)

HOOK UP

Hook up with Cain & Company's specialized capabilities in the microwave field. Cain & Company provides a unique nationwide network of applications specialists . . . full-range microwave systems and component coverage. The result: faster, better assistance in your microwave system design problems. Through its nationwide representation of SPERRY ELECTRONIC TUBE DIVISION, REMANCO, TRAK ELECTRONICS and TRAK MICROWAVE, Cain & Company offers the most advanced klystrons, traveling wave tubes, backward wave oscillators, miniature microwave signal sources, harmonic multipliers, radar simulators, beacon test sets, radar performance monitors and specialized receivers. Your nearby Cain & Company application specialist will be glad to help you. Give him a call.

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Offices in: **NEW YORK** (Great Neck), **CHICAGO**, **ST. PETERSBURG**, **BOSTON** (Lexington), **PHILADELPHIA**, **WASHINGTON, D.C.**, **DAYTON** (Yellow Springs), **DALLAS** (Irving), **ALBUQUERQUE**, **SAN FRANCISCO** (Los Altos), **SAN DIEGO**, **SEATTLE**

THE SYMBOL OF NATIONWIDE INSTRUMENTATION SERVICE

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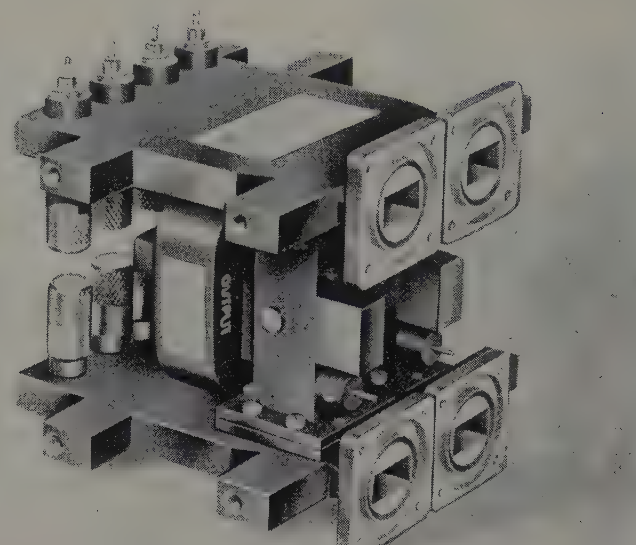
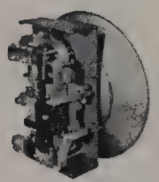


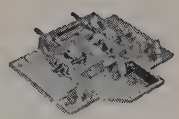
PACKAGED PRECISION FOR YOUR EXACT REQUIREMENTS

MICROWAVE SUB-SYSTEMS

Kearfott has the experience and ability to design precision sub-systems to the customer's actual configuration and performance needs. The availability of a wide variety of standard components, coupled with advanced techniques, makes it possible to provide packaged r-f assemblies with a high component density—tailored to precise volumetric specifications. For minimum size and weight in airborne or missile applications — for military system environment—Kearfott will successfully design your sub-system—to your most exacting requirement.

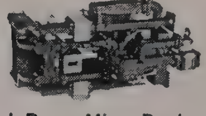


Mono-Pulse Radar



S-Band Strip-transmission Head

Mixer Duplexer



High Power Mixer Duplexer

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Circle Reader Service Card 35

Industry News

(*Continued from page 48*)

MORGAN FORMS MICROWAVE CAVITY LABORATORIES

Robert Morgan, microwave consult announces the formation of his own c pany, Microw Cavity Labora ies, Chicago, Il

One of the ginal founders J. V. M. Microw Co., which was cently acquired the Fidelitone crowave, Inc., gan resigned position as president and c engineer.

Microwave Cavity Laboratories will fer a line of triode cavities including os lators, amplifiers and multipliers in t series, narrow and extended range. addition the line will include associa microwave components. The empha will be placed on quality, performa and availability at a reasonable cost.

The new 6000 sq. ft. plant in suburb Chicago was occupied November 1st. ticular emphasis has been placed up adequate financing, competent engineer and capable production facilities.

—*mwj*—

AIR FORCE TO RAISE CONTRACT SAVINGS REWARDS, COST PENALTIES

The United States Air Force, in caref ly chosen cases, will allow higher pro to defense contractors who save taxpay money and exact corresponding penal of those whose costs exceed estima members of the Electronic Industries As ciation have learned.

Sessions of military electronics pro cers at the EIA fall conference in the B more Hotel were told that, under a n policy, the Air Force also may all higher profits for superior performance terms of delivery time and product qu ity, and may correspondingly penal poor performance.

Industry representatives were inform that fees up to the statutory limit of percent of cost on research and devel ment contracts and 10 percent on prod tion contracts might be allowed for ext ordinary good performance. On the ot hand, a company whose cost performa was poor would be subject to a scale penalties up to the full amount of his f and perhaps more in some cases.

The new policy represents a sharp parture from previous Air Force practi which limited profits to a maximum about 9 percent on cost-plus-incentive contracts and also restricted rewards fixed-price-incentive contracts.

—*mwj*—

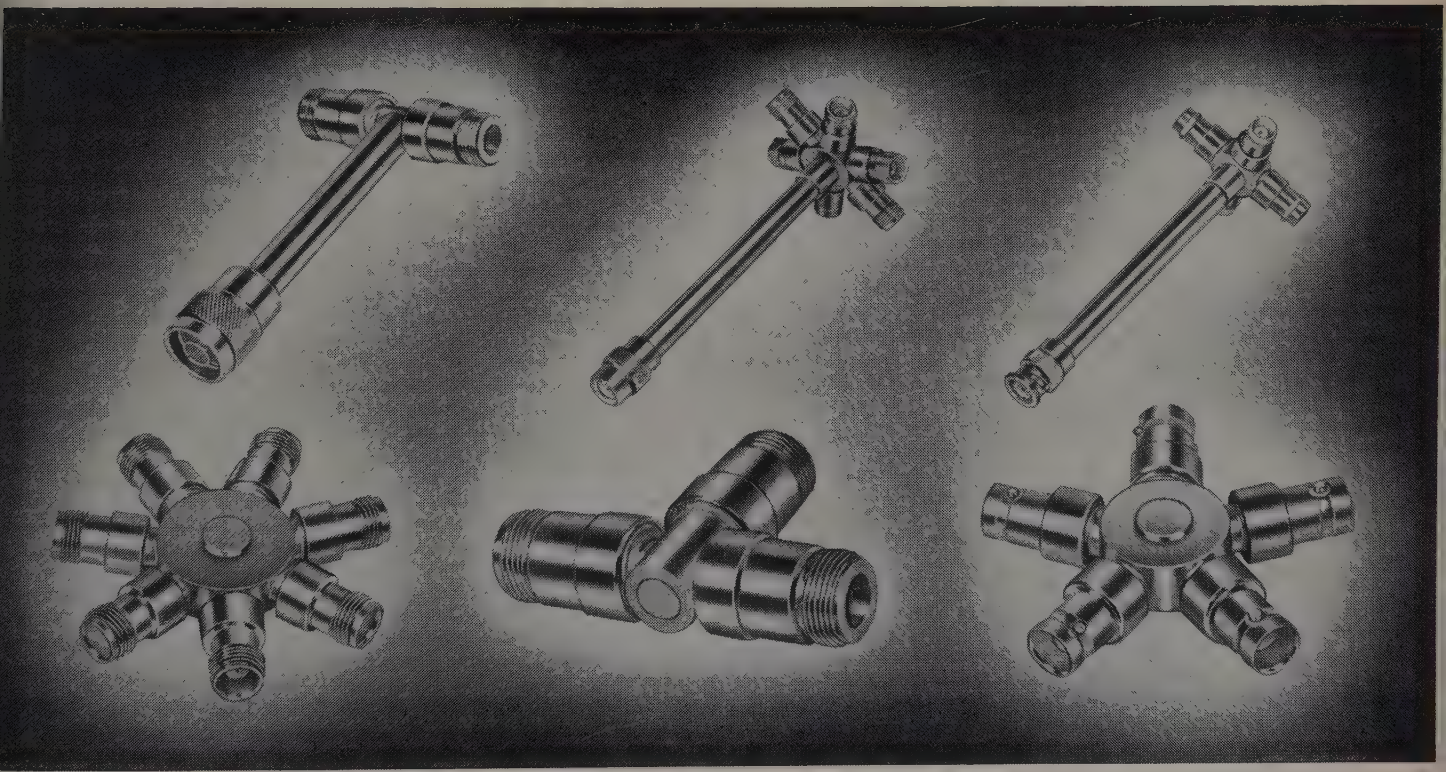
(*Continued on page 53*)

POWER DIVIDERS

IMMEDIATE DELIVERY

MICROLAB MAINTAINS COMPLETE INVENTORIES OF REACTIVE AND RESISTIVE POWER DIVIDERS FOR IMMEDIATE DELIVERY. THE REACTIVE DIVIDERS ARE LOW LOSS UNITS AVAILABLE IN STANDARD FREQUENCY RANGES FROM 250 MC TO 10,000 MC WITH 2, 3, 4, 5 AND 6 OUTPUTS. THE RESISTIVE DIVIDERS-COMBINERS ARE WIDE BAND DEVICES OPERATING FROM DC TO 3000 MC AND ARE AVAILABLE WITH 3, 4, 5, 6 AND 7 ARMS.

FOR COMPLETE ELECTRICAL AND MECHANICAL SPECIFICATIONS AND APPLICATION INFORMATION WRITE FOR CATALOG NO. 10.



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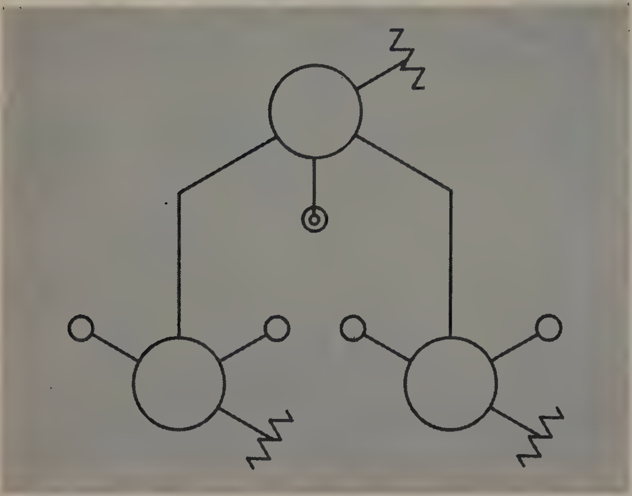
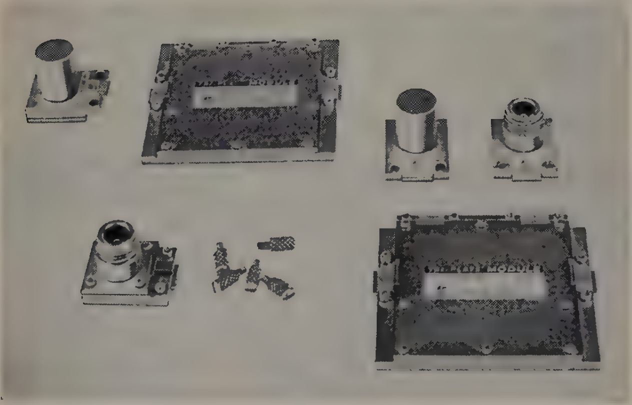
MAKE NEW MICROWAVE IDEAS PAY OFF SOONER

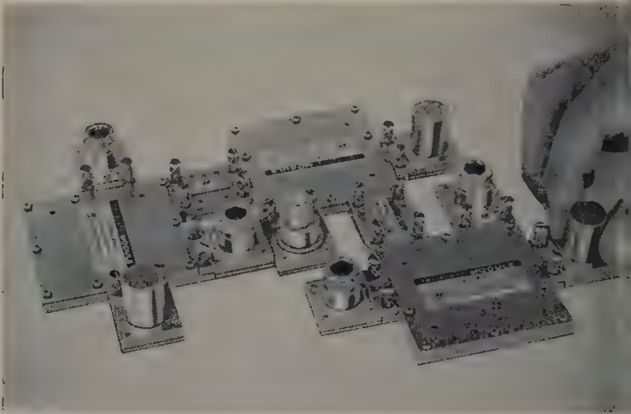
right through production! with Sanders' exclusive strip transmission line techniques and services!



YOUR NEW CIRCUIT IDEAS for microwave applications . . . no matter how new, different or daring . . . can now be breadboarded and tested without costly waste of time, effort and money. All you need is a kit of off-the-shelf . . .



. . . **BREADBOARDING MODULES!** These exclusive Sanders TRI-PLATE strip transmission line components . . . standard or custom-engineered . . . include hybrid rings, power dividers, bends, directional couplers, attenuator pads, coax transitions, mounts for transistors, tunnel diodes, varactors and switching diodes, etc. . . . all with integral connectors. You assemble them in minutes with thumbscrews.



WORKING CIRCUIT built with modules ready to test! This su assembly is a balanced, single-end mixer. It could just as well b an oscillator, pulse amplifier, down converter, harmonic generat parametric amplifier . . . or a radically new microwave developme of your own. Performance matches that of conventional plumbin as much as ten times larger and heavier.

PRODUCTION PROTOTYPE ready for quantity production! Unitized TRI-PLATE "packages" like this 4-way power divider for broad band operation at frequencies up through X band, feature low radiation and cross talk, precise reproducibility and mil-spec reliability. It weighs 1/10 as much, takes 1/10 the space of waveguide and at less cost.

QUANTITY PRODUCTION of customized TRI-PLATE "packages" employs automated photo-etching techniques. It reduces costs fa below those of coaxial and waveguide units. Sanders' complet TRI-PLATE service . . . modules, engineering, production . . . i always on call. Write for your complete TRI-PLATE Data File wit specifications and prices today to: Microwave Products Dept Sanders Associates, Inc., Nashua, New Hampshire.

SANDERS TRI-PLATE® STRIP TRANSMISSION LINE

Breadboarding Modules . . . Custom-Engineering . . . Quantity Production

®Sanders Associates, Inc.

(*Continued from page 50*)

ANTENNAS DESIGNED FOR EUROPEAN COMMUNICATIONS SYSTEM

Twelve tropospheric scatter communiation antennas are scheduled to play a ital role in a multi-million dollar U. S. Air Force communications link from England to Spain.

The antennas were specially designed by Blaw-Knox Co., Pittsburgh, Pa., and fabriated in England under the supervision of Blaw-Knox Limited.

Eight of the units are 60-foot parabolic ntennas capable of withstanding at least 50-mph winds and six inches of radial ce, while the four 120-foot diameter units re capable of withstanding at least 200-mph winds with 24 inches of radial ice — while maintaining extremely close tolerances.

The project will make high quality voice circuits available; and tie in with a commercial telephone system at air bases in England, and at repeater sites in Spain. The "Senorita" network, between northern Africa and southern Spain, will also be incorporated in the new system.

— *mwi* —

RAYTHEON TO INSTALL MICROWAVE RELAY LINK FOR SWEDEN AIR DEFENSE

Microwave relay links to strengthen Sweden's air defense network will be produced and installed by Raytheon A. G. under a contract awarded recently by the Royal Swedish Air Force Board.

Raytheon A. G. is the sales and service subsidiary of the American firm's Raytheon Europe division.

Similar in design to units recently installed by Raytheon in Switzerland, Denmark and Norway, the Swedish relays will transmit data gathered at remote surveillance sites to central operations centers.

The relays can beam substantial amounts of data through the air from point to point. In commercial use, they can handle radio, telephone, telegraph, television and facsimile transmissions.

— *mwi* —

PORTS AND MISCHLER ELECTED DIRECTORS AT WHITE

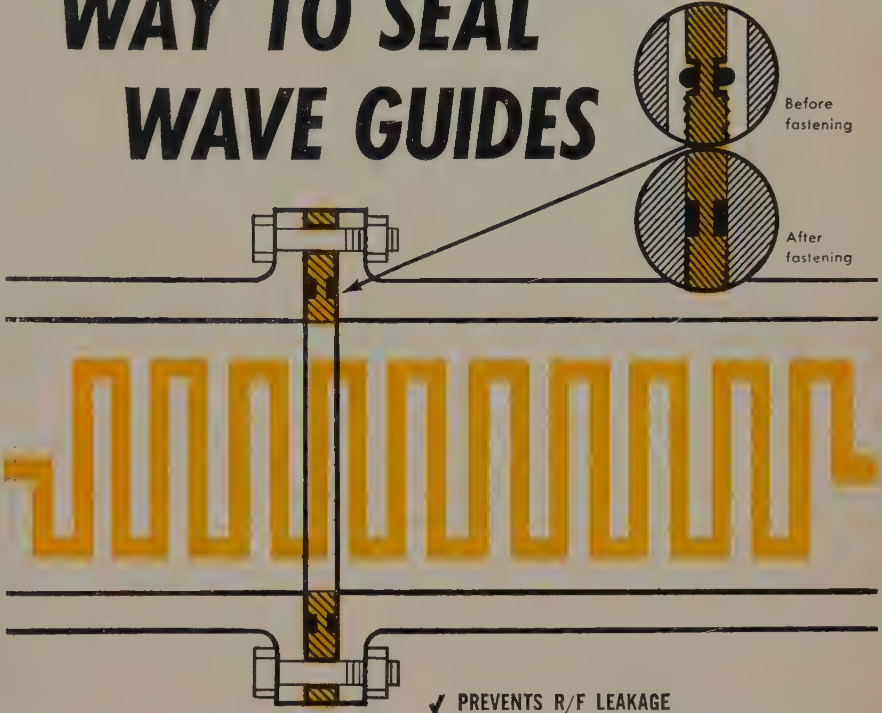
Delmer Ports, vice president of Jansky & Bailey, Division of Atlantic Research Corp., and Edward Mischler, vice president of National Engineering Service, have been elected directors of White Electromagnetics, Inc., Bethesda, Md., it has been announced by Don White, president.

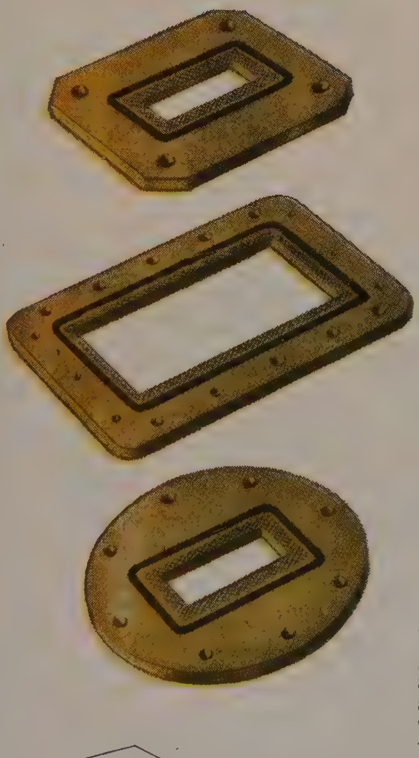
The firm which recently changed its name from Don White Associates to White Electromagnetics, Inc., deals principally in RFI prediction and control, space communications systems and design, weapons system evaluation, system evaluation by computer simulation, and other phases of systems analysis.

— *mwi* —

(*Continued on page 54*)

NOW THERE IS A BETTER WAY TO SEAL WAVE GUIDES





✓ **PREVENTS R/F LEAKAGE**
Metal-to-metal contact with "engraved fingers" on inside surfaces assures electrical continuity.

✓ **PROVIDES NO-LEAKAGE SEALING**
Controlled confinement of seal gland assures safe, sure, positive sealing — **exceeds** top hermetic specs!

✓ **ELMINATES ARCING AND/OR BURNING**
Designed to exacting requirements for proper mating of flanges as specified.

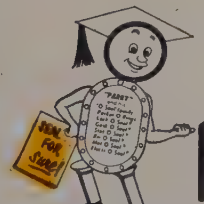
✓ **CAN BE RE-USED**
Seal is never "squeezed" beyond elastic limits, "memory" is constant, before, during and after fastening.

✓ **ECONOMICAL**
Eliminates cleaning or resurfacing flanges, no intricate machining required to accommodate the seal, and they're resuseable with just normal care.

✓ **STANDARDS FOR W/R SERIES**
Electr-O-Seals are available as standards to WR series Wave Guide flanges, assuring adequate supply and economy.

In addition to the standard WR series wave guide flange seals, Parker Seal Company also makes special seals to meet almost any specification or configuration. A nation wide group of field engineers are available to aid in expediting your requirements.

For more complete information send for catalog 5801.


SEAL FOR SURE!

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

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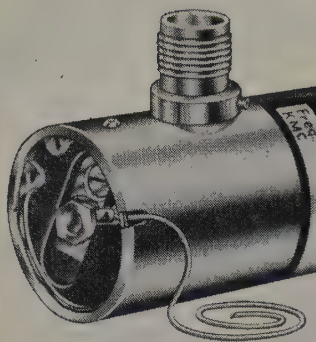


TRAK TYPE 2970 (CW)
Diameter 7/8″, Length 2″
Weight 3 Ounces

TRAK STOCK ITEM:

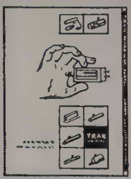
Our Smallest Oscillator To Tune Entire C-Band

Our smallest local oscillator to tune the entire C-Band is now in production. It features high overall power efficiency and more power output than was previously available. It can be furnished with temperature stabilities of less than 1 Mc total drift for 100°C temperature change.

TYPICAL SPECIFICATIONS

FREQUENCY:	Tuneable from 5.2 Gc to 6.0 Gc by adjusting a screw located on one end of the C-Band Cavity.
POWER OUTPUT:	Greater than 10 mw from 5.4 to 5.9 Gc. Greater than 5 mw over the entire band.
POWER INPUT:	175 V DC at approximately 13 ma; 6.5 V @ 240 ma.
TEMPERATURE STABILITY:	Less than ± 2 Mc drift from −20°C to + 105°C. Greater stability available.
MOUNTING:	Engineered to customer specifications.

WE'D LIKE TO TACKLE YOUR ENERGY SOURCE PROBLEMS — Trak Microwave specializes in engineering and manufacture of microwave oscillators, power amplifiers and harmonic generators using both solid state and tube techniques. Inquiries invited.
PHONE COLLECT: TAMPA 876-6422 or TAMPA 876-6407.



Typical stock oscillators are included in Catalog 61-A, giving specifications, illustrations and performance curves. Immediately available upon request.

TRAK® Microwave

TRAK MICROWAVE CORPORATION
5006 N. COOLIDGE AVENUE
TAMPA 3, FLORIDA

Specialists In Miniature Microwave Energy Sources

(*Continued from page 53*)

CORNING GLASS WORKS FORMS RADOME DEPARTMENT

The manufacture of missile radomes h been given department status by Corni Glass Works, Corning, N. Y.

Manager of the new Radome Depa ment is Raymond A. Wasson, who h headed the operation from its beginni He will continue to be responsible for dome engineering, production and sale

The operation previously was a part Corning's New Products Division, whe Wasson was product manager for a craft and missiles. The newly-formed partment will operate as a part of t company's Technical Products Divisior

Wasson joined Corning in 1938. Fro 1944 to 1952 he was manager of the firm Parkersburg, W. Va., plant, then w transferred to the New Products Divisio in Corning, N. Y. He was graduated 1938 from Colgate University with a B degree.

— *m w j* —

GAGNOT WILL STREAMLINE BUDGETING SYSTEMS FOR NARD

In a major step to improve its operati procedures, The Narda Microwave Cor Mineola, N. Y., has announced the appointment of Peter J. Gagnot as Controller.

Mr. Gagnot will be responsible for streamlining the corporation's budgeting systems and all phases of profit planning, cost standards, systems and procedures and formulating accou ing policies.

"The appointment of Mr. Gagnot controller is a major step forward in a suring maximum efficiency of operations according to William A. Bourke, preside of Narda. "A well-engineered financi program, geared to a fast, simple and a curate cost reporting system," he adde "has been the key to better manageme decisions and rising profits in many con panies."

— *m w j* —

GENERAL RAILWAY SIGNAL ACQUIRES BUDELMAN ELECTRONICS

The General Railway Signal Compan Rochester, N. Y., announced that it ha purchased the Budelman Electronics Corp Stamford, Conn.

Budelman will be operated as a wholl owned subsidiary of General Railway Sig nal under its present management, wit William Fingerle, president, and Barn S. Trott, vice president.

Organized in 1951, Budelman specia izes in point-to-point multi-channel radi and wire line communication systems fo

(*Continued on page 57*)

TRG

MILLIMETER MICROWAVE COMPONENTS...26 to 220 kmc •

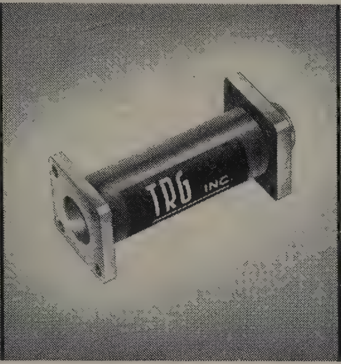
Whatever your problem in millimeter waves — a component or complete systems development — TRG has more of everything it takes, including experience, to put the answers right in the palm of your hand.

Model V-160 Circulator

FERRITE DEVICES: The TRG four port circulator illustrated is typical of our complete line of ferrite devices covering the 26 to 140 kmc band. Unit pictured operates at 75 kmc with 20 db isolation, 1 db loss, and 1.3 VSWR. 3% band

- **Complete ferrite duplexers**
- **Four port circulators**
- **Three port reciprocal switches**
- **Variable attenuators**
- **Modulators**
- **On-off switches**
- **Isolators**

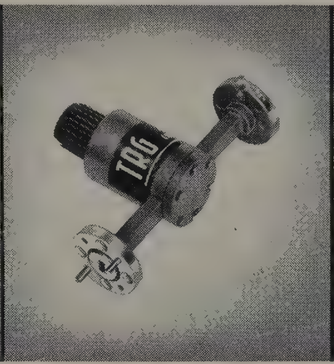
Model V-340 Mode Filter



LOW LOSS CIRCULAR WAVEGUIDE COMPONENTS: For millimeter systems involving long waveguide runs, low loss TE_{01} circular waveguide components reduce waveguide losses to usable levels. TRG has all the components necessary for a TE_{01} circular waveguide system.

- **Mode filters**
- **Corrugated bends**
- **Rectangular to circular mode transitions**
- **Rectangular to TE_{11} transitions**
- **Rotary joints**

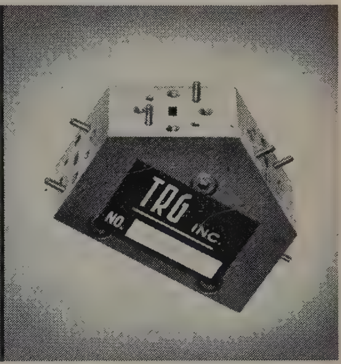
Model V-520 Attenuator



TEST BENCH: A complete line of millimeter components for test bench measurements over the 26 to 220 kmc band.

- **Slotted lines**
- **Directional couplers**
- **Wavemeters**
- **Variable attenuators**
- **Precision attenuators**
- **Phase shifters**
- **Detector mounts**
- **E/H tuners**
- **Slide screw tuners**
- **Sliding short circuits**
- **Transitions**
- **Tees**
- **Twists**
- **Bends**
- **Terminations**
- **Drill jigs**

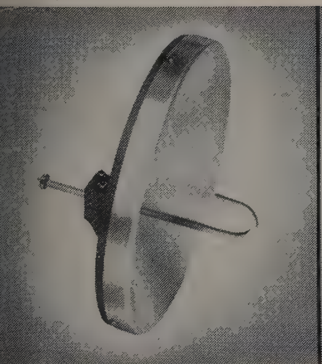
Model V-600 Hybrid Ring



SYSTEMS COMPONENTS: A complete line of systems components for millimeter radar applications.

- **Duplexers**
- **Single hybrid rings**
- **Triple hybrid rings**
- **Balanced mixers**
- **Waveguide switches**
- **Ferrite switches**
- **Antennas**
- **Rotary joints**
- **Flexible waveguides**
- **Receiver front ends**
- **Dual mode transducers**

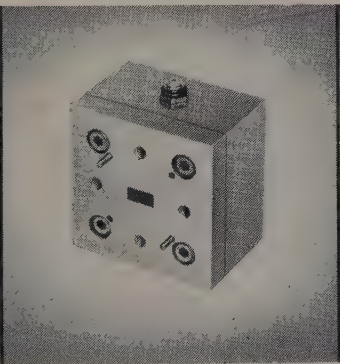
Model F-806 Antenna



ANTENNAS: TRG has total capability in millimeter antennas. The 6 inch diameter unit pictured operates at 140 kmc with a one degree beamwidth. Antennas are available in the 26 to 220 kmc band.

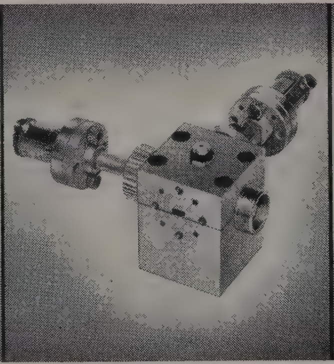
- **Horn-fed paraboloids 3″ to 36″**
- **Waveguide slot arrays**
- **Conical scan antennas**
- **Monopulse antennas**
- **Circular polarized feeds**
- **Linear-circular polarized feeds**
- **Solid dielectric lenses**
- **Electroformed gain standards**

Model A-990 Bolometer



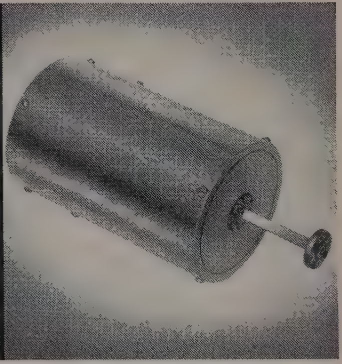
BOLOMETERS: TRG bolometers are available over the entire 26 to 220 kmc band. The in-guide construction eliminates noisy finger contacts and dielectric windows protect the delicate element from air currents and dust. These are the most sensitive video detecting elements known in the millimeter region.

Model V-730F Harmonic Mixer



HARMONIC MIXERS AND GENERATORS: TRG harmonic mixers and generators incorporate a diode element mounted directly into the waveguide structure. Mixers are available for second to eighth harmonic mixing. These devices are useful for stabilizing millimeter sources, with lower frequency standards, calibrating millimeter frequency meters with lower frequency standards and serving as the front ends of millimeter receivers in the 26 to 220 kmc region.

Model V-980 Calorimeter



CALORIMETERS: TRG water calorimeters are useful laboratory standards for absolute power measurements in the millimeter bands. The measurement technique employs a DC substitution method in a balanced bridge circuit.

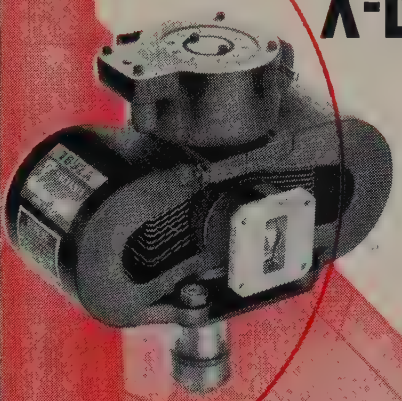
RG **TECHNICAL RESEARCH GROUP, INC., ANTENNA & MICROWAVE DEPT.,** 9 Union Square, Somerville, Massachusetts — Phone: MOnument 6-8680

NEW!

Unique tuner design of

X-Band Tunable Magnetron

improves airborne radar performance



**Provides: linear tuning; precision tunin
low thermal drift, freedom from vibratio
resonance, rugged, reliable structure**

Sylvania-7692A is a highly stable pul
magnetron offering 220KW peak po
output over the 8550 to 9650MC ra
It combines a remarkable *new tuner*
sign with *proven dispenser type cath*
in a rugged package capable of withsta
ing heavy shock and excessive tempe
tures. (Tests to date indicate 300°C ca
bilities.)

Inductive Post Tuner, a Sylvania design,
vides linear tuning, simplifying local os
lator tracking, eliminating associated c
pensating equipment of coupled ca
designs. Features include: a single bell
that tunes all posts simultaneously—sec
and precise alignment of tuning posts
means of a guide ring that also serves
an effective heat sink—free tuning p
length restricted to 0.200 inches, elimin
ing electrical and mechanical resonan
at very high frequencies—electrically a
thermally grounding the tuning posts
very low thermal drift.

Reliable dispenser type cathode, incorpora
in Sylvania-7692A, features low hea
power requirements, therefore low cath
temperatures, high stability, outstandi
life. Cathode memory is of extremely sh
duration—abrupt switches in pulse len
do not detract from cathode performa
or life. Too, the molybdenum cath
support is virtually unyielding to vib
tional stresses, exhibits very low heat l
permitting zero heater voltage operat
at rated operating current.

Vacuum firing up to 1000°C of individual pa
prior to assembly effectively de-gasses e
ments, contributing to reliability and
exceptional starting stability of appro
mately 0.05% average missing pulse cou

Additional X-band, tunable types from Sylva
include: 7006, 210KW peak power outp
M-4164, 220KW peak power output; 76
220KW peak power output. Presen
under development are significant refi
ments to the 7692A, including a hydr
lically tuned version.

In short, the intensive magnetron devel
ment program underway at Sylvania
serves your close investigation. Cont
your Sylvania Sales Engineer for up-
the-minute information. For tech data
specific types, write Electronic Tubes Di
sion, Sylvania Electric Products In
1100 Main St., Buffalo 9, N. Y.

TYPICAL OPERATION—SYLVANIA-7692A

Duty cycle	0.001	
Pulse width	1.0	µsec
Rate of rise of voltage	200	KV/µsec
Avg. anode voltage	27.5	mAdc
Peak anode voltage	22.0	KV
Avg. power output	220*	W
Pulling factor	12	MC
Pushing factor	0.25	MC/A

*Min. power output—200W

SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

GENERAL
SYSTEM

(*Continued from page 54*)

e by industry, government agencies and ilities. Budelman's products include F, VHF and microwave FM and AM nsmitters and receivers, duplexers, tele-one carrier, radio multiplex, automatic nsfer, protector and emergency power nels, voice frequency repeaters, cabinets d test equipment.

— *m w j* —

KOCH NAMED DIRECTOR OF MARKETING AT LITTON

David G. Koch has been named director marketing for the Litton Industries ectron Tube Division, San Carlos, Cal., cording to John S. McCullough, assist ıt to the general manager.

Koch will direct the marketing of klysons, magnetrons, traveling wave tubes ıd other microwave and display devices, hich are key components in radar, comunications, navigation and other vital efense systems.

Koch comes to Litton Industries from e Electron Tube Division of Radio Cororation of America, Lancaster, Pa. He as associated with RCA for more than 3 years in engineering, sales and marketg positions, most recently as manager market planning for microwave tubes.

An electrical engineering graduate of e University of Wisconsin, Koch reeived his masters degree in industrial anagement at Stevens Institute of Techology, Hoboken, N. J. He also comleted a graduate course in sales and mareting management at the University of yracuse.

He is a member of the Institute of adio Engineers.

— *m w j* —

UANTATRON DIVISIONS OCCUPY NEW FACILITY

Quantatron, Inc., Santa Monica, Cal., as recently moved two divisions and a holly-owned subsidiary into a single 7,000 square foot building at 2520 Coloado Avenue, Santa Monica.

Leasehold improvements in this large, odern plant have been completed in reparation for occupancy by Quantatron's pplied Physics and Microwave Laboraories as well as for its subsidiary, Donan Electronics Inc.

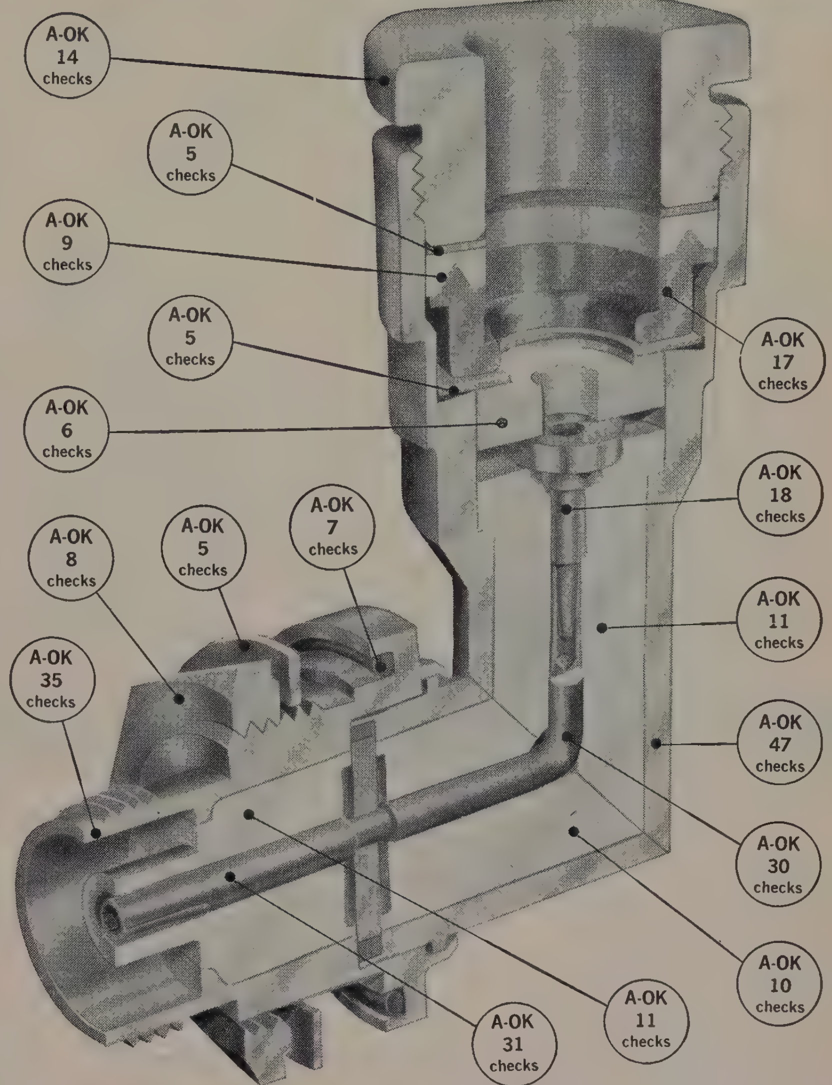
The leasehold improvements include a odern laboratory for Laser and Maser esearch and development. This laboraory is equipped with the latest scientific ols for materials research (e.g. spectroopy and crystal growing) to support the aser work of the Applied Physics Laboraory team headed by Dr. T. H. Maiman, ventor of the Ruby Laser and pioneer in aser technology.

The major part of the new plant will e occupied by the Microwave Laboratory ıd its division, Don-Lan Electronics.

— *m w j* —

(*Continued on page 59*)

A-OK···273 TIMES!



Gremar RF Connectors must pass an average of 273 quality checks before they're passed on to you.

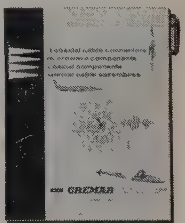
Gremar connectors stand out in reliability because they stand up to the stiffest quality control checks in the industry. From selection of materials to final assembly, every component part must pass the "All O.K." checkout scores of times before we're willing to stamp "Gremar" on the connector. *This is why our connectors are specified in every major defense program in the country!*

RELIABILITY PLUS DELIVERY

If you specify RF connectors with critical reliability requirements Gremar can help you. If it's a *standard* it's probably in stock. If it's a *special* it *may* be in stock — if not, we're geared to make it up fast! If it's a new design we can engineer it and build it in our model shop — fast! Gremar's 58 page Quality Control Manual details scores of quality control checks that insure extraordinary reliability and performance in our connectors.

NEW TIME-SAVING MANUAL

If you specify or purchase RF Connectors, send for the most concise, conveniently organized listing available in the field.



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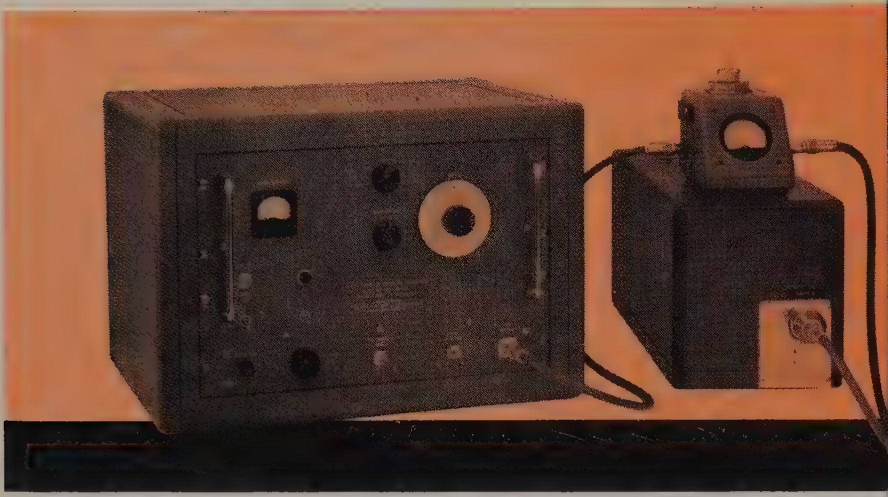

Sierra 290B Test Set

Frequency coverage dc through 12.4 KMC.

Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

Data and prices subject to change without notice. Prices f.o.b. factory.

Laboratory setup above shows Sierra Model Power Source being used in conjunction Model 290B Calorimeter to calibrate Sierr Directional Power Monitor. Designed sp cally for calibration purposes, 215 series Sou include four 50 watt models covering, co tively, 25 to 1,000 MC. Model 215A, 25 t MC; Model 215B, 50 to 150 MC; Model 2 150 to 470 MC; Model 215D, 470 to 1,000 Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

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6560

sierra

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(*Continued from page 57*)

YTTRIUM IRON GARNET ADVANCES REVEALED BY BELL SCIENTISTS

A significant advance in the understand- of yttrium iron garnet (YIG), a ma- ial that provides a substantial improve- nt over ferrites in many electronic plications, was revealed by Bell Tele- one Laboratories scientists at the Inter- ional Conference on Magnetism and ystallography held recently in Kyoto, pan.

The advances were described in an in- ed paper by R. C. LeCraw and E. G. encer. YIG is similar to the ferrites that it is both ferrimagnetic and an ctrical insulator, but it has a different ystal structure and is a much better in- lator. Both types of material transmit crowave radiation with very little loss.

LeCraw and Spencer reported ferromag- tic resonance linewidths of only 0.14 rsteds at room temperature and 6000 Mc YIG—the narrowest linewidth ever re- rted for a ferrimagnetic material. The 14 oe. linewidth of YIG is many times rrower than that reported for the best rrites, which have linewidths of about oe.

LeCraw and Spencer found that surface ughness of YIG crystals had a large ef- ct, and that the residual linewidth at w temperatures is caused by ferrous ns. By polishing the crystals to an ex- emely smooth finish and developing ethods of removing impurities, the Bell ientists succeeded in lowering the line- idth to 0.14 oe.

The measured linewidth now agrees osely with a recently developed theory, cept at very low temperatures, and they lieve that this figure is the intrinsic line- idth of perfect YIG.

— m w j —

LEWIS WILL MANAGE STROELECTRONICS LABORATORY

Clarence H. Lewis has been appointed anager of the Westinghouse Electric rp.'s astroelectronics laboratory in ewbury Park, Cal., it has been an- unced by N. V. Petrou, general mana- r of Westinghouse air arm division. r. Lewis replaces Jack E. Darr who is urning to the air arm engineering de- rtment in Baltimore, Md.

Mr. Lewis was graduated from the iversity of Illinois with a BS degree in ctrical engineering and a Master of ience degree in communications and ctronics. He has been director of tech- cal services at the astroelectronics lab- atory in Newbury Park since he joined estinghouse a year ago.

Mr. Lewis is a senior member of the E, and a member of the Armed Forces mmunications Electronics Association.

— m w j —

(*Continued on page 61*)

ISOLATORS

from
2.6GC
to 40GC
...broadest
line of
waveguide
test
equipment isolators

■ All of your ferrite test equipment isolator needs are available promptly — competitively priced — from Ferrotec. In 8 waveguide sizes from 2.6GC to 40GC. Unique design provides rugged mechanical construction and a high degree of magnetic stability. New developments include coaxial test equipment isolators with octave bandwidth coverage in 3 units, from 1GC to 8GC.

Shown: x-band isolator *Write for Data Sheet*

Frequency Range MC	Waveguide Size	Isolation Min. db	Insertion Loss Max. db	VSWR Max.	Model No.	Price
2600- 3950	RG-48/U	20	1.0	1.20	I-151L	$340
3950- 5850	RG-49/U	25	1.0	1.15	I-152L	$240
5850- 8200	RG-50/U	30	1.0	1.15	I-153L	$220
7050-10000	RG-51/U	30	1.0	1.15	I-154L	$195
8200-12400	RG-52/U	30	1.0	1.15	I-155L	$190
12400-18000	RG-91/U	30	1.2	1.15	I-156L	$260
18000-26500	RG-53/U	25	1.5	1.15	I-157L	$280
26500-40000	RG-96/U	20	2.0	1.15	I-158L	$320

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Design • Development • Production
of microwave ferrite components

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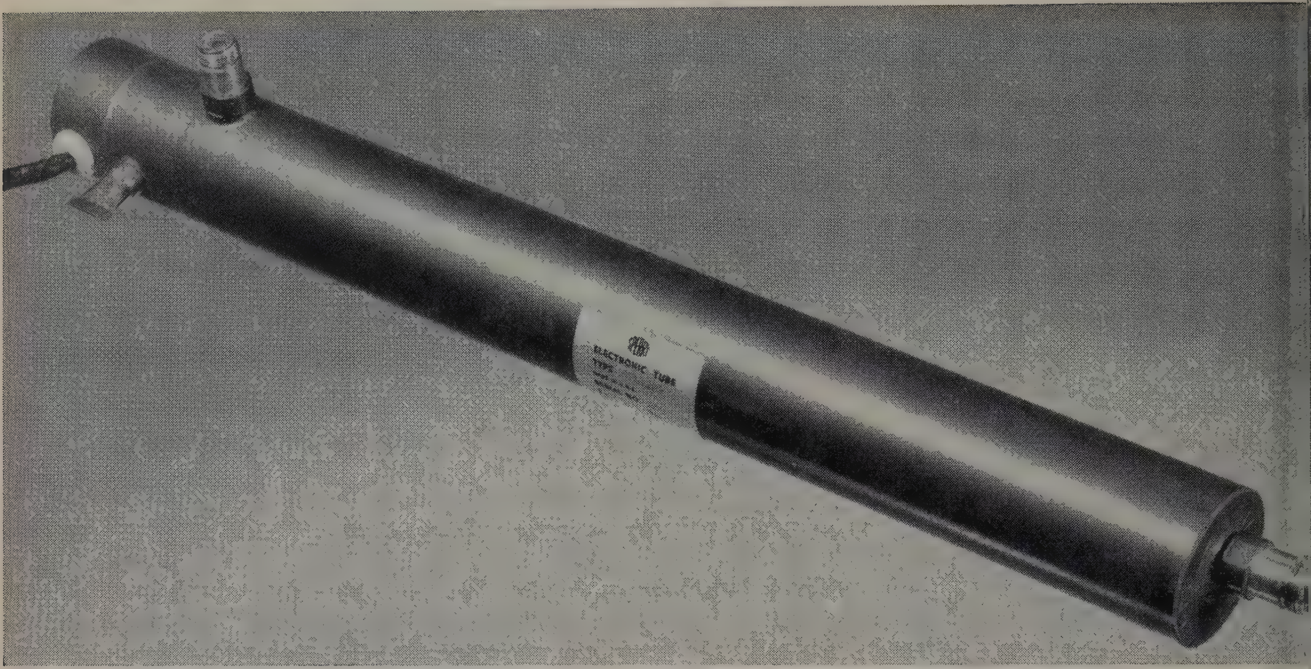
SPERRY ELECTRONIC TUBE DIVISION **microwave memo**

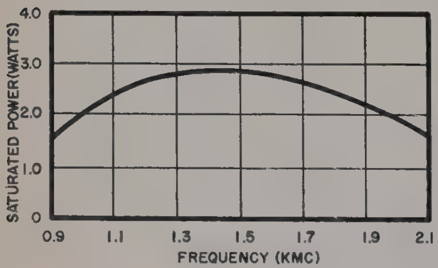


Sperry extends 30-day delivery to cover ECM and augmenter TWT's operating in L, S, and X bands

In a dramatic extension of its capability for delivering high-performance microwave tubes on short notice, Sperry Electronic Tube Division has added three system-proved traveling wave tubes to the list of those available in 30 days. Included in the move are tubes operating in L, S, and X bands. They cover a frequency range 1.1 to 11.0 kMc.

APPLICATION FLEXIBILITY

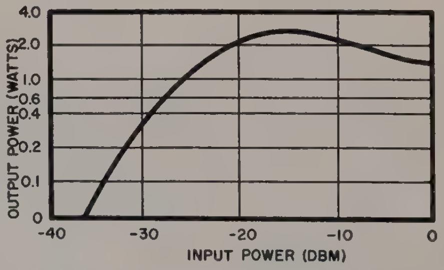
The tubes in this series are particularly suited to application in augmenters and ECM equipment. The inherent broadband characteristic and unusual ruggedness of these PPM focused tubes makes them unusually versatile in airborne applications. A full course of MIL and environment tests, as well as considerable in-system experience have verified these characteristics.



A typical saturated power versus frequency curve for an L band Sperry TWT.

INCREASED POWER POSSIBLE

Although these tubes nominally operate in the 1-2 watt power output range, optimum tuning can increase power to as much as 5 watts. A high-mu control grid adds to the versatility of these tubes by allowing rem switching, modulation control gain adjustment.



Drive characteristics at mid-band for a typical Sperry ECM/augmenter TWT.

SYSTEM DESIGN SIMPLIFIE

Use of these Sperry tubes gre simplifies system design probl Low voltage and high gain rec power supply requirements. Appl tion is further simplified, since ar ent cooling is sufficient in most ap cations and the tubes may be mou in any position.

For FREE technical information on t Sperry Traveling Wave Tubes, writ Section 603, Sperry Electronic Division, Gainesville, Florida.

The L-Band tube is priced at $1, the S-Band tube at $2,195., and X-Band at $2,540.

For application assistance and c tation, consult your nearest Cai Co. representative. His address phone number appear on the oppo page.

SPERRY ELECTRONIC TUBE DIVISION
GAINESVILLE, FLA. / GREAT NECK, N.
SPERRY RAND CORPORATION

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San Diego, California
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Seattle, Washington
Phone MA 3-3303

SPERRY
ELECTRONIC TUBE DIVISION
SPERRY RAND CORPORATION

(Continued from page 59)

WILCOX IDENTIFICATION EQUIPMENT SELECTED BY FRENCH AIR FORCE

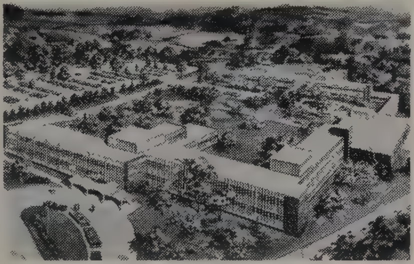
The radar identification equipment of the Wilcox Electric Company, Kansas City, Mo., has been selected by the French Air Ministry for installation in the Mirage IIIC fighter planes for the French Air Force, Jay V. Wilcox, president, has announced.

An agreement has been signed with Le Materiel Telephonique, the French subsidiary of the International Telephone & Telegraph Company, for the interchange of technical knowledge in the field of radar identification for military aircraft.

The equipment, Wilcox disclosed, will be manufactured by Le Materiel Telephonique under a license and royalty agreement. The initial contract with the French government calls for the production of "several hundred sets of equipment, starting early in 1962," Wilcox said.

— *m w j* —

SYLVANIA DEDICATES NEW BUILDINGS VIA ELECTRONICS



Dedication of new headquarters and Applied Research Laboratory facilities of Sylvania Electronic Systems, Waltham, Mass. was performed electronically. A microwave signal, received and retransmitted by a simulated communications satellite, automatically unveiled bronze dedication plaques which will be permanently installed in the new buildings.

A message from Gene K. Beare, president of Sylvania, was relayed by the "space-borne" system to the more than 400 persons present. The device attached to the satellite, which passed over the heads of the assembled guests in a "controlled orbit," is a modified version of a telemetering unit developed by the Applied Research Laboratory.

The Opening of the new facilities, totaling 115,000 square feet represented a high point in the commemoration this year of the 60th anniversary of Sylvania's founding in the state of Massachusetts.

Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc., is engaged in research, development, product enginering, manufacturing, field engineering and training activities in advanced electronic fields.

— *m w j* —

SPECTRAN ENTERS FIELD OF MAGNETOSTRICTION ELECTRONIC DEVICES

The formation of Spectran Electronics Corp., Maynard, Mass., for the development and manufacture of magnetostriction components and instruments has recently been announced by six founders who have held important positions in this field.

Spectran products will include multiple-filter spectrum analyzers for sonic and electromagnetic waveform studies; magnetostriction rod filters for frequency reference, analysis, and signal selection; and magnetostrictive delay lines for use in digital computers, and in radar and communications systems. The firm will also offer research and product development services in this fast-growing field.

Heading the Spectran group is T. A. O. Gross, president, who has been with Raytheon Company as manager of electromechanical components operations, and as manager of advanced development in the Missile Systems Division. Mr. Gross has served as a consultant to the Department of Defense on magnetics and electronics, and holds 25 U. S. and foreign patents in these fields.

An 11,000 sq. ft. facility is now being set up for development and production activities of Spectran Electronics Corp. It will include a precisely-controlled constant-temperature assembly area for the processing of critical magnetostrictive devices. The Spectran plant is located in Maynard, Mass., at 146 Main St., in the midst of a growing group of electronics companies.

— *m w j* —

GE WILL EXPAND SOUTHERN RAILWAY'S MICROWAVE FACILITIES

General Electric Company has been awarded a new contract for approximately $6 million to expand microwave facilities of the Southern Railway System.

Under the agreement, G-E's Communication Products Department, Lynchburg, Va., will supply a multi-channel transistorized communications design built for high channel capacity. It will be used in a new microwave network to be installed by Southern between Cincinnati, Ohio; Atlanta, Ga.; and Birmingham, Ala.

The announcement was made in Washington by the railway's executive vice-president, D. W. Brosnan, who said the Southern Railway System will spend a total of $7.9 million on its latest communication project.

Southern's microwave and mobile radio contract with General Electric calls for completion of the new program in October of 1962. An earlier microwave system now being installed by General Electric for Southern Railway at a cost of $5 million will be completed between Washington and Atlanta early next year.

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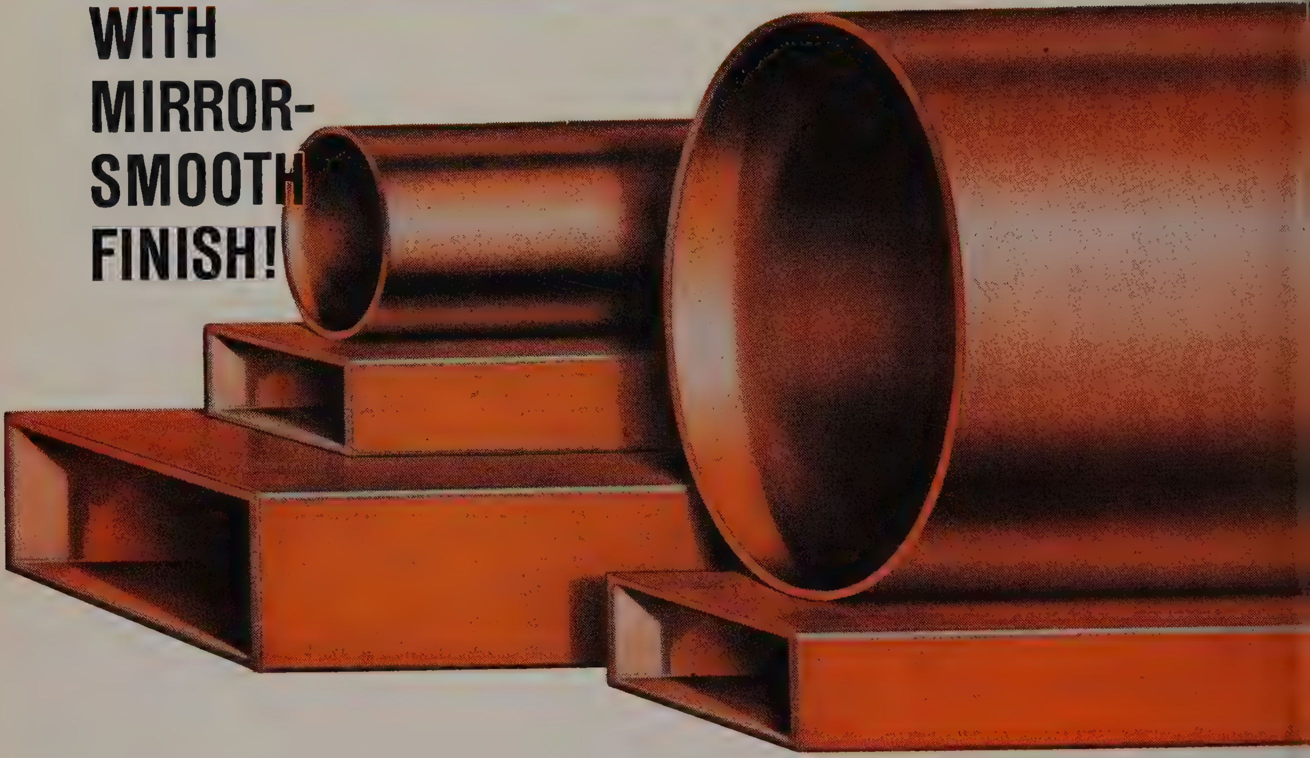
FINISH!



Phelps Dodge has expanded its precision-crafted line of waveguides to include circular as well as rectangular seamless shapes. Both types are carefully extruded and individually cold drawn from oxygen-free copper and commercial bronze to closest tolerances.

Through close control of the ID tolerances and surface, Phelps Dodge assures top performance at high frequencies. Phelps Dodge offers the widest variety of sta ard sizes for both rectangular and circular waveguid Both types are available in 12-foot stock lengths, a longer lengths on special order. Minimum mill quan is 500 lbs. per size for oxygen-free copper, and 1,000 for commercial bronze.

PHELPS DODGE COPPER PRODUCTS
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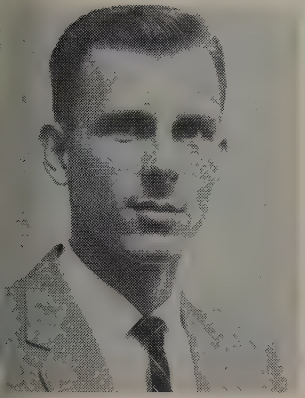
CONTRIBUTORS IN THIS ISSUE



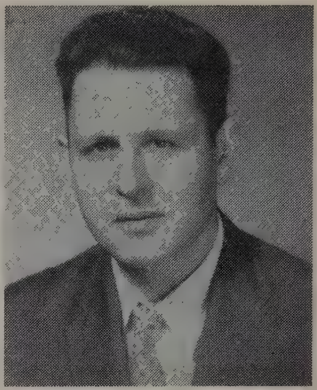
J. BROWN was born in Auburn, Alabama in 1932. He received his BS degree in electrical engineering in 1954 from Auburn University and his MS degree in electrical engineering from the Georgia Institute of Technology in 1959. From 1954 to 1957 he was a Naval aviator.

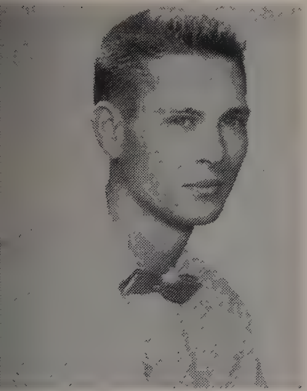
Mr. Brown joined Sperry Microwave Electronics Company as a Senior Engineer in 1959. Since that time he has done supporting research work in the field of parametric and ferrimagnetic devices and, in particular, ferrimagnetic limiters.

RTHUR O. McCOUBREY is manager of Research and Advanced Development t Bomac Laboratories, Inc. He received his BS degree in applied physics at the alifornia Institute of Technology in 1943 and joined the Westinghouse Research aboratories where he participated in the development of radar duplexer and freuency reference components. In 1953, Mr. McCoubrey received his PhD degree n physics at the University of Pittsburgh.

While at Westinghouse he participated in several fundamental studies of basic rocesses in atomic and molecular physics, optical resonance radiation and millimeter vave phenomena in super conductors. In 1957 he joined National Co., to work on he precise control of frequency by atomic resonance, as well as other applications f resonance physics. He joined Bomac Laboratories, in his present position, in ugust, 1960.

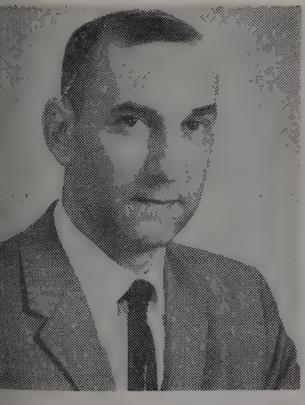
Mr. McCoubrey is a member of the American Physical Society and the IRE.





RONALD F. MUEHLBERGER is presently completing studies for his BS degree in electrical engineering at Northeastern University. He graduated from the Franklin Technical School in 1958. Since then he has been employed at General Radio Company under the Cooperative Plan of Education.

Under the Cooperative study plan at Northeastern, Mr. Muehlberger alternates ten-week periods of in-school study with equal periods of on-the-job training.



JOHN ZORZY received his MS degree in physics from Tufts College in 1950 and his BS degree in physics from George Washington University in 1948. From 1950 to 1954 he was employed as senior engineer at Trans-Sonics, Inc., Bedford, Mass.

He joined the Microwave Laboratory of Hughes Aircraft Company in 1954 and directed the design and test of interceptor and missile radomes. In 1956 he rejoined Trans-Sonics, Inc., now in Burlington, Mass., to continue radar work, and directed the flight test of the radar at Holloman Air Force Base, N. M.

After completion of this project in 1959, he joined AVCO, RAD in Wilmington, Mass., as principal scientist for the development of re-entry vehicle antenna systems. During the latter part of 1959, he was employed as a section head in the Solid State Physics Branch of the Advanced Development Laboratory, Missile Systems Division, Raytheon Company, Bedford, Mass.

In 1960, he joined General Radio Company and is presently engaged in the development of microwave equipment.

He is a member of Sigma Xi and Sigma Pi Sigma.

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PRD 680 CALORIMETRIC POWER METER!

With this new instrument you can measure power accurately and directly, from a few microwatts up to a half watt. No bolometers, barretters, thermistors, or external attenuators are necessary. Nine power ranges can be selected on the front panel dial, and direct power reading in DB or watts can be made in seconds. Instrumentation is accurate to 2%. A lightweight (20 lbs.), easily portable unit, the PRD 680 utilizes the PRD series of dry calorimeters which plug into the front panel interchangeably. Shown here is the N680, covering the range of 0 to 10 kmc/sec. Waveguide plug-in units for X and K bands will be available soon. Send for data!

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MILLIWATTS
NEW FROM PRD

FREQUENCY CONTROL BY MICROWAVE ATOMIC RESONANCE

A. O. McCOUBREY
BOMAC LABORATORIES, INC.
Beverly • Massachusetts

INTRODUCTION

The extensive development of the microwave spectrum has made possible important strides in many well established areas of technology. Among these, the control of frequency has been advanced with outstanding results, and the limits are evidently well beyond the achievements already made.

Modern methods of precise frequency control constitute an application of the new engineering discipline of "Quantum Electronics." This entire field of activity has come into existence mainly on the strength of microwave technology, a circumstance arising from the fact that many of the finer details of the energy states of matter, particularly those which are strongly coupled with electromagnetic fields, involve frequencies in the microwave spectrum. In most cases, these energy states involve the fine details of electronic motion in atoms or groups of atoms ranging from molecules to entire crystals. There exist also many examples of nuclear motion at microwave frequencies.

Modern advances in microwave engineering have made it possible to gain access to new areas of experimental physics, and in turn, the resulting applications have given rise to ingenious additions to the expanding family of microwave components and devices. For example, the frequency control developments of interest here have led to the cesium atomic beam resonator, a high vacuum microwave tube having a great deal in common with other microwave tubes used for power sources or amplifiers. Frequency control masers, in the past, have also led to component tubes, and certain new developments hold forth the promise that these devices will have outstanding importance in the future. Likewise, gas filled microwave resonance cells constitute an important new component group.

The rapid development of microwave frequency control techniques has led to some lack of understanding concerning the relative merits of various methods and the true nature of their differences. In the present article we shall attempt to establish, qualitatively, the physical foundations of the most advanced approaches and then compare them, and suggest the outlook for their further development.

Before proceeding to this task, it is worth noting that quartz crystal oscillator improvements in recent years have been significant.[1,2] However, it is most unlikely that the long term aging effects characteristic of these devices will ever be eliminated to the very high degree possible in atomic osillators. Recently, it has also become evident that the spectral purity of signals from quartz crystal oscillators, as it is affected by noise from various sources, is exceeded by that of some atomic devices. This trend will become established to an even greater extent as time passes and straightforward refinement of the atomic oscillators is carried out.

ATOMIC FREQUENCY CONTROL SYSTEMS

Atomic frequency standards fall into two broad classes involving active atomic resonators on one hand and passive resonators on the other. The active devices are masers which provide a signal consisting of stimulated emission of microwave energy from the atomic particles. In frequency control masers studied so far, the signal intensity of the direct output is too low for practical applications and additional electronic apparatus is required to increase the available power. Ammonia masers[4] and the recently invented atomic hydrogen maser[14] are examples of active frequency control devices.

Passive atomic resonators are designed to stabilize conventional oscillators by the use of feedback control circuits as indicated in Figure 1. The spectral characteristics of the controlled signal are, of course, influenced by the nature of the feedback circuits as well as the response function of the resonator. Ammonia microwave absorption cells, rubidium optical absorption cells, and cesium atomic beams have all been used as passive resonators.

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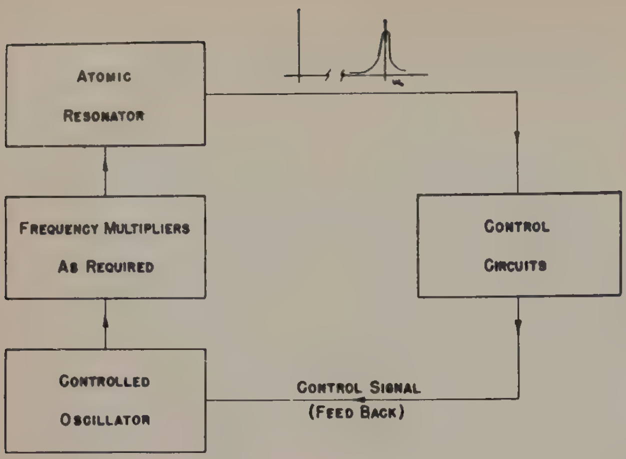

Figure 1 — The application of a passive atomic resonance device to the frequency control problem.

In this article we shall be concerned with the various atomic resonators and their relative characteristics. While associated electronic circuit characteristics affect performance of active as well as passive devices, the basic qualities must be found in the resonators which we shall discuss.

QUANTUM MECHANICAL RESONANCES

The possibilities for controlling frequency by quantum effects were widely recognized following the Second World War when the first accurate results in microwave spectroscopy were obtained. Since the early experiments involved ammonia-filled waveguide absorption cells, efforts were made to devise oscillators stabilized by them.[19] However, the sharpness of resonance, or the Q, of these devices was limited by the kinetic molecular collisions within the cell. Such collisions constitute energy relaxation processes which limit the period of time during which any given quantum mechanical particle is useful as a resonator. The perturbation-free interaction time between the atomic particle and the microwave field is, without doubt, the most important single feature which determines its merit for the control of frequency.

Longer interaction periods between the atomic particles and the microwave fields were first provided by atomic and molecular beams, an approach which is particularly free of spurious relaxation processes. Passive beam resonators for frequency control were studied by Zacharias[3] and his coworkers, and devices based upon them have reached a stage of considerable engineering refinement. Townes[4] and his coworkers first demonstrated maser action with beams of ammonia molecules and these devices have been widely studied[20,21] as frequency standards for some time. At present it appears unlikely that ammonia beam masers will ever be used to any great extent in this application. The reasons include the influence or pulling[4] of the operating frequency which accompanies detuning of the microwave cavity. While criteria for correct microwave tuning can be established,[23] the engineering complexities introduced by their automatic use are excessive. It is also desireable to operate the ammonia maser with $N^{15}H_3$ instead of the abundant $N^{14}H_3$ in order to achieve a symmetric form for the quantum mechanical resonance.[22] The engineerin complexities associated with the need to circulate suc ammonia cyclically through the device are also unwieldy especially in view of the fact that no performance advantage is gained compared to other techniques.

Long interaction times between the microwave field and the atomic particles may also be provided by trappin them within materials, or volumes bounded by material which do not cause relaxation of the important energ states. Dicke first suggested[6] the use of buffer gases reduce the Doppler broadening of radiation from certa magnetic dipole transitions. By the choice of buffer gase having no magnetic properties, such as noble gases, it i also possible to eliminate relaxation processes resultin from the collisions. Rubidium buffer gas cell resonato have been studied[7] extensively for frequency control purposes, the interaction time in these devices being th period during which the active rubidium atoms diffus through the buffer gas to the walls of the cell.

A few years ago Ramsey pointed out[8] that resonanc cells having walls coated with materials which produc no relaxation of the magnetic energy states during collisions of the active atomic particles would also produc extremely sharp microwave resonance free of Dopple broadening. Recently it has been found[14] that certai wall materials are sufficiently effective in the case o hydrogen atoms that maser action involving interactio times of almost one second has been achieved, and i seems likely that, in the near future, considerably longe periods of interaction will be realized. Atomic hydroge masers now appear to have the greatest potential as frequency standards, and engineering refinements are i progress.

At the present time, then, the atomic frequency standards under intensive development involve the cesium atomic beam, the rubidium buffer gas cell, and the atomi hydrogen maser. It is sufficient to confine attention t these devices in the remainder of this paper and procee to a brief qualitative outline of their physical foundations Fortunately, they all have a great deal in common, making our task relatively easy.

Physical Principles

The microwave quantum effects of interest to us aris from the nuclear magnetic hyperfine structure of th electronic ground state of the atoms involved. We ar dealing with hydrogen or one of two alkalai metals, al of which have the hydrogen-like spectra characteristic o atoms with a single valence electron. The ground electronic state in these cases does not contribute magneti effects due to orbital motion of the electrons. There exists, however, a magnetic force acting between the valence electron and the nucleus in each case, arising from the electron spin dipole moment and the nuclea spin dipole moment. Accordingly, there is a slight variation in the energy of the ground electronic state which depends upon the orientation of the electron dipole moment with respect to the nuclear dipole moment. For quantum mechanical reasons, only two such orientations are available to the electron dipole moment, and the corresponding magnetic energy shifts, in the absence of

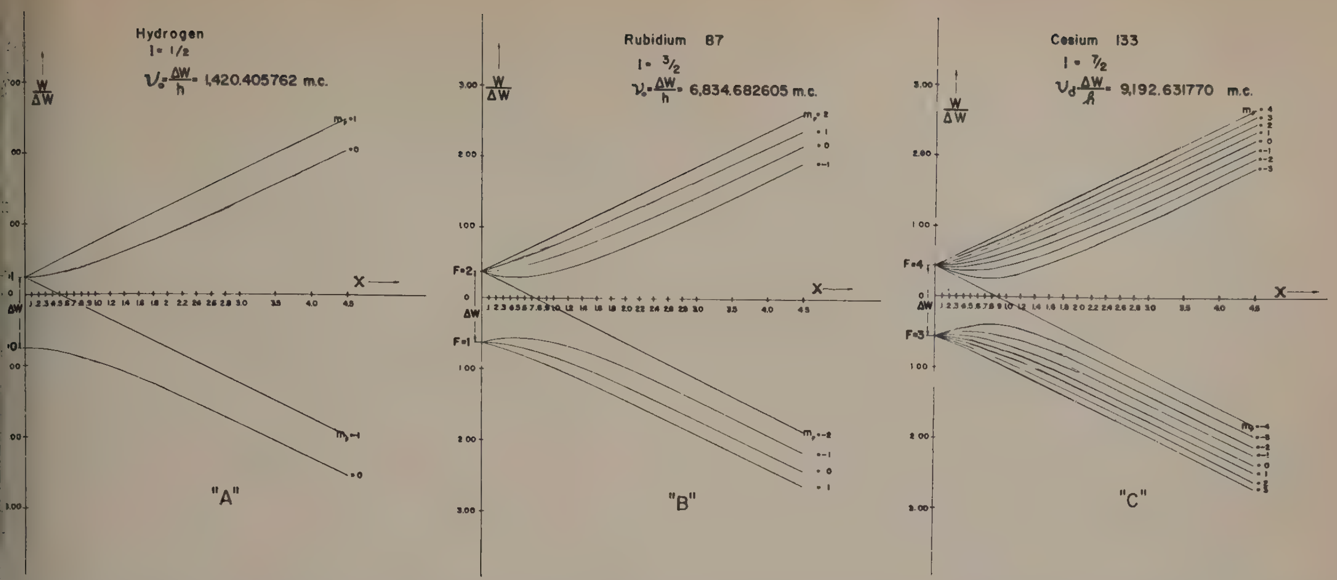

Figure 2 — The Zeeman splitting of the hyperfine energy levels of the ground electronic states of hydrogen, rubidium and cesium. The various energy curves are very closely given by the relationship,

$$\frac{W(m_F)}{\triangle W}+\frac{1}{2I+1}=\pm\frac{1}{2}\sqrt{1+\frac{4m_F}{2I+1}X+X^2}$$

where $X=\dfrac{2\mu_e B_E}{\triangle W}$ is a dimensionless measure of the external magnetic field, I is a quantum number related to the nuclear angular momentum, F is a quantum number related to the total angular momentum of the entire atom, and m_F, the magnetic quantum number, is related to the component of the total angular momentum in the direction of the external field, B_E

xternal magnetic fields, are given by

$$\triangle E=\pm\frac{\vec{\mu}_e\cdot\vec{\mu}_N}{r^3} \tag{1}$$

where $\vec{\mu}_e$ and $\vec{\mu}_N$ are the electronic and nuclear dipole moments and r is the effective atomic radius at the site of the valence electron. Thus, it turns out that the elecronic ground state of the atoms of interest to us are plit into two levels as the result of the internal atomic particle configuration, and the frequencies corresponding o the energy difference lie in the microwave spectrum. When external magnetic fields are applied to these atoms, hese states split into additional levels corresponding to he various possible orientations of the entire atom with espect to the external field. The number of such orienations which are possible depends upon the total anguar momentum of the entire atom which, in the present ase, corresponds to the vector sum of the electron spin nd the nuclear spin momenta. There are quantum mechanical limitations on the number of discrete orienations allowed in nature; however, these details are not of particular interest here.

The magnetic hyperfine energy structure which we have just mentioned is summarized in the Zeeman diagrams of Figure 2. For each case, in the absence of an xternal magnetic field, there are two energy levels coresponding to the two possible spin orientations of the valence electrons within the atomic structure. In the presence of an external field, the two levels in each case plit into the larger number indicated. It may be noted hat all of the energy levels for which $m_F=0$ leave the ero magnetic field axis with zero slope. Transitions between these levels, in each case, provide the best opportunity for making frequency standards because the corresponding frequencies are least dependent upon fields arising from the environment.

We may gain qualitative insight into the nature of the quantum mechanical motion within the atom and the influence of microwave magnetic fields upon it by examining the motion of the valence electron as influenced by the magnetic field which acts upon it. There are two components of the steady field whose vector sum must be considered, one, B_N, being a few thousand gauss and arising from the nearby nuclear dipole, and the other, B_E, a few milligauss arising from the environment. It turns out, in the case of the states for which $m_F=0$, that the two components are orthogonal and their resultant is closely given by

$$B=B_N\left[1+\frac{1}{2}\left(\frac{B_E}{B_N}\right)^2\right] \tag{2}$$

The valence electron experiences a torque, $\vec{\mu}_e \times \vec{B}$, which tends to align its dipole in the field direction. Being a gyroscopic particle, it can only respond by gyrating about the field direction as illustrated in Figure 2. The angular frequency of the gyration, often referred to in physics as the Larmor frequency, is given by

$$\omega_L=\frac{2\pi\mu_e}{hs}B \tag{3}$$

where μ_e is the electronic dipole moment and hs, the product of Plank's constant and the electron spin quantum number, is simply the mechanical angular momentum of the spinning particle. Introducing equation (2)

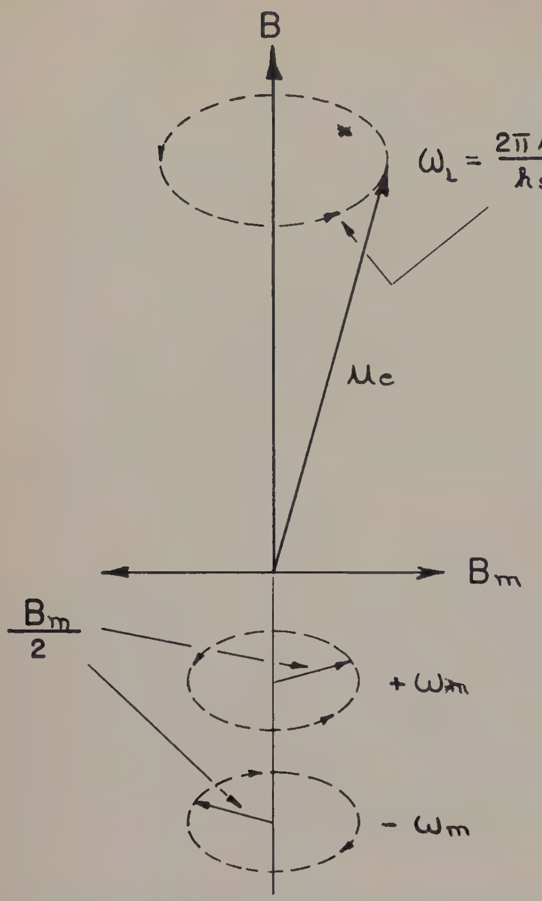

Figure 3 — The interaction of an electron with d.c. and microwave magnetic fields.

into (3) we have

$$\omega_L = \frac{2\pi\mu_e}{hs} B_N \left[1 + \frac{1}{2}\left(\frac{B_E}{B_N}\right)^2 \right] \quad (4)$$

The Larmor precession given by equation (4) is the fundamental periodic motion of the atomic oscillators we are concerned with. In the case of the active type of device, energy is derived directly from this motion. The very high degree of frequency stability of the atomic oscillations is due to the stability of the quantities which enter into equation (4). Except for the magnetic fields, only natural constants are involved. The field at the site of the valence electron due to the nucleus, B_N, is not only constant but also the same in all atoms of the same species which are not distorted in shape by environmental forces. The environmental magnetic field, B_E, in the case at hand enters as a second order effect and under practical conditions its influence can be extremely small.

It is of interest next to explore the action of the magnetic component of a microwave field upon the valence electron precessing within the atom. It is usually convenient to create a linearly polarized microwave field in a specified direction by means of waveguides or cavities. Such a field, represented by B_m in Figure 3, may be decomposed into two circularly polarized components consisting of radial magnetic vectors, $\frac{B_m}{2}$ rotating in opposite senses at the microwave angular frequency, ω_m. To understand the effect of these circularly polarized fields upon the atom valence electron, it is helpful to make transformation of coordinates which is equivalent climbing aboard the electron and gyrating with it. Th circular components of the microwave field then, course, appear to have different frequencies. For th case of $\omega_m = \omega_L$, that component which rotates in th same sense as the gyrating electron becomes synchroniz with it and in the transformed, rotating coordinates appears as a steady d.c. field of intensity $\frac{B_m}{2}$. Under th condition, within the rotating coordinates, the valen electron executes another precession, this time about th microwave field vector at a rate given by

$$\omega_f = \frac{2\pi\mu_e}{hs} \frac{B_m}{2} \quad ($$

If the microwave interaction is arranged to last for ju such a time, T_f, that the precession given by equation (goes through π radians, the valence electron will ha "flopped" over in its orientation within the atom. Th condition for this is,

$$\omega_f T_f = \pi$$

or

$$B_m T_f = \frac{hs}{\mu_e} \quad (6$$

There remains a question concerning the effect of th circular component of the linearly polarized microwa field which rotates in the sense opposite to the electro gyration. Within the rotating coordinate system, th component appears to have twice the microwave fr quency, and its tendency to "flop" the electron is r versed during each cycle. The effect, averaged over a significant time interval, is essentially zero.

The foregoing discussion applies specifically to a reso ance condition in which the frequency of the applie microwave field is the same as the Larmor frequency the valence electron within the atom. For neighborin microwave frequencies, the degree of "flop" in a give interaction period is smaller and the behavior may described in terms of a resonance function comparab to those encountered in electromagnetic circuits. T sharpness of the resonance function, or its Q, must explained physically in terms of the Heisenberg Unce tainty Principle. However a qualitative argument can based upon the Fourier spectrum of the microwave fie to which the atom is exposed. For short interactio times, T_f the atom is exposed to a short pulse of micr wave radiation with the result that it will experien spectral components distributed widely on either side the microwave frequency, and the effective flopping fr quency can be found in a correspondingly wide rang of applied microwave frequencies. In this case, the Q low. On the other hand, for long interaction times, T the atom will be exposed to a spectrum which is mo completely clustered about the microwave frequency an a correspondingly small range of applied frequencies wi be effective in causing flop. In this case the Q is high an the essential importance of the interaction time to a atomic resonator is evident.

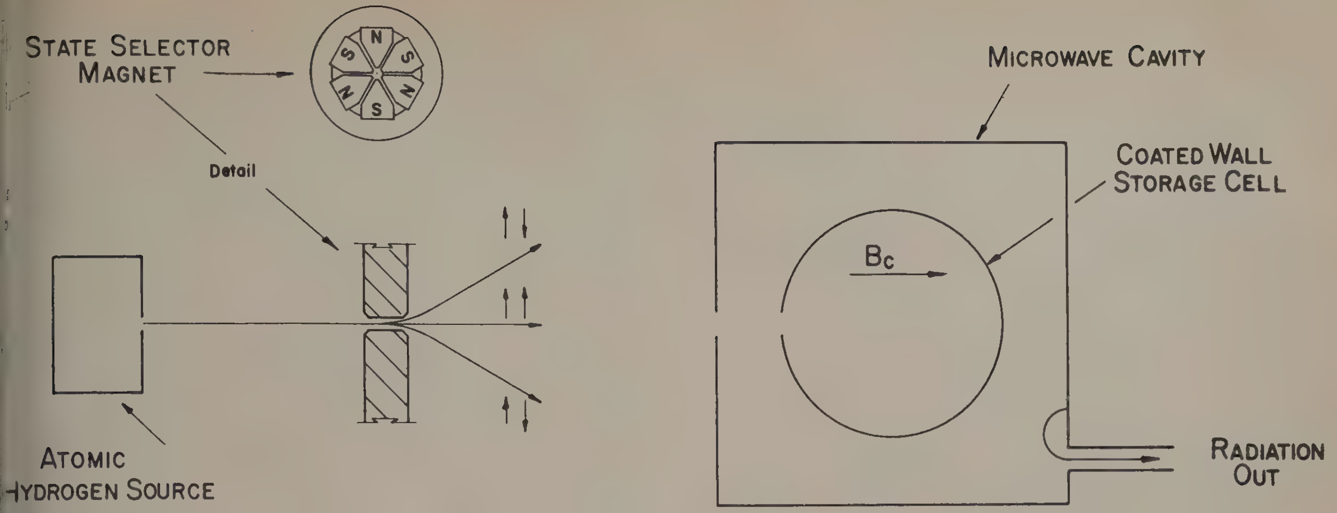

Figure 4 — The atomic hydrogen maser.

We have now completed an outline of basic physical principles which are common to modern atomic frequency control resonators based upon hyperfine resonance in hydrogen, rubidium and cesium. We may now proceed to sketch the different arrangements for observing the effects of interest.

ATOMIC RESONATOR APPARATUS

The essential functions of the apparatus in all the cases of interest here include:

1. Selection of atoms in the required state;
2. Exposure of these atoms to the microwave field;
3. Sensing the effect of the exposure.

Two of the devices share a common method of achieving the first function, while they all differ with regard to the other functions.

Atomic Hydrogen Maser[14]

A functional sketch of the atomic hydrogen maser is given in Figure 4. Dissociated hydrogen atoms from an electric discharge source are formed into a beam and passed through a state selector which exposes them to a high magnetic field gradient. Referring back to Figure 2 (a) for a moment, the potential energy of the atoms is dependent upon the magnetic field they are in, and a force, given by the gradient of the potential energy, and therefore also dependent upon the field gradient, acts upon the atoms of the beam. It is evident from Figure 2 (a) that atoms in one group of states will be forced towards the region of low field along the axis of the state selector sketched in Figure 4, while the other group is forced radially outward. The former group, represented by the symbol ↑↑ in Figure 4, contains the useful atoms in the state $F=1$, $m_F=0$.

The beam containing hydrogen atoms in selected states is passed into a quartz cell having its walls coated with a material which is highly inert with respect to hydrogen. The inert characteristics of such materials must be such that chemical binding forces which would cause the hydrogen atoms to be adsorbed are not effective. Further, magnetic wall forces must be absent in order to avoid relaxation of the atomic hydrogen magnetic hyperfine states during collisions. The materials which have been found to be effective so far include certain paraffins and dimethyldichlorosilane.[14]

Within the coated wall storage cell, the atoms make random transits, being reflected upon each encounter with the walls. During the process, they interact with the microwave field within a cavity surrounding the storage cell. This interaction continues until the atoms radiate and give up their energy usefully to the microwave field, relax by colliding with some imperfection of the wall, relax by collision with another of their kind or a magnetic impurity, or wander out the opening through which they entered the storage cell. In atomic hydrogen masers which have been operated so far,[14] these relaxation factors have been controlled to the extent that interaction periods approaching $T_m = 1$ second have been achieved. The corresponding resonance Q is in the neighborhood of 10^9.

The long interaction time, free of spurious relaxation processes, permits coherent stimulation of the hydrogen atoms and sustained maser oscillation. The power level which is available is about 10^{-12} watts.

In order to be sure that only the $F=1$, $m_F=0$ states in the selected atoms contribute to the maser action and to avoid certain low energy radiation events, a small, uniform, steady magnetic field is provided in the interaction region by coils which are not illustrated in Figure 4. Shields to eliminate other environmental fields are likewise not shown. It must also be understood that, except for the atomic hydrogen, the space within the maser is highly evacuated and there are provisions to remove expended hydrogen.

The wall collisions during the interaction period will lead to a small shift in frequency from that which would be expected for hydrogen atoms not perturbed in this way. Once determined, this shift is not important for most practical applications unless it changes in time and produces aging effects. The origin of the wall collision shift involves the distortion of the atomic configuration and it is analogous to collision shift experienced in buffer gas cell resonators. The collision frequency, and therefore the anticipated shift, is very much smaller in the case of the hydrogen maser due to the long transit paths

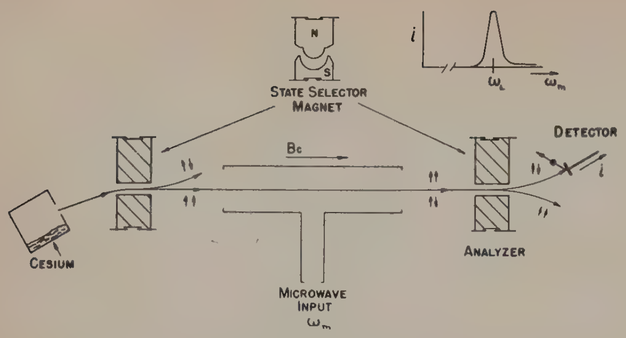
N
S
State Selector Magnet
i
ω_L
ω_m
Detector
Bc
i
Cesium
Analyzer
Microwave Input
ω_m

Figure 5 — The cesium atomic beam resonator.

across the cell, which must be compared with mean free paths in the gas diffusion case.

The Cesium Atomic Beam Resonator[5,12,16]

Figure 5 represents the essential features of a cesium atomic beam tube. A beam is formed from atoms evaporated from the liquid metal. As in the case of the atomic hydrogen maser, those atoms of the beam which are in the required state, $F=4$, $m_F=0$, are selected in a strong, inhomogeneous magnetic field and then passed into a microwave cavity where interaction with the magnetic component of the microwave field takes place. Following the interaction period, the beam passes through a second state selecting magnet which serves to analyze the beam for quantum mechanical changes. Those atoms whic have flopped into the $F=3$, $m_F=0$ state as the result o resonance in the cavity are directed to a detector wher they are converted to a signal current. The resonanc response of the beam signal as a function of the applie microwave frequency, ω_m, is illustrated in Figure 5 an the functional characteristics of this signal form the bas of the automatic control of the oscillator frequency ind cated in Figure 1.

For the same reasons cited in the case of the atom hydrogen maser, a small, external, steady magnetic field B_c, is applied in the interaction region by conductors no illustrated. The space within the cesium tube is al highly evacuated and provided with means to absorb e pended cesium. The conversion of the neutral cesium beam signal into an electric current in the detector based upon the surface ionization of cesium by certai hot metals.[15]

The resonance Q of the cesium atomic beam resonato through the interaction time, depends upon its lengt and the velocity of the beam atoms. Tubes have bee made which are about two meters in total length an which have Q's in the neighborhood of 10^8. In the cas of tubes of about two feet in total length, the Q's ar about 2×10^7.

Rubidium Buffer Gas Cell Resonator[7]

The rubidium buffer gas cell resonator is represente in Figure 6. Rubidium vapor is contained within a cel

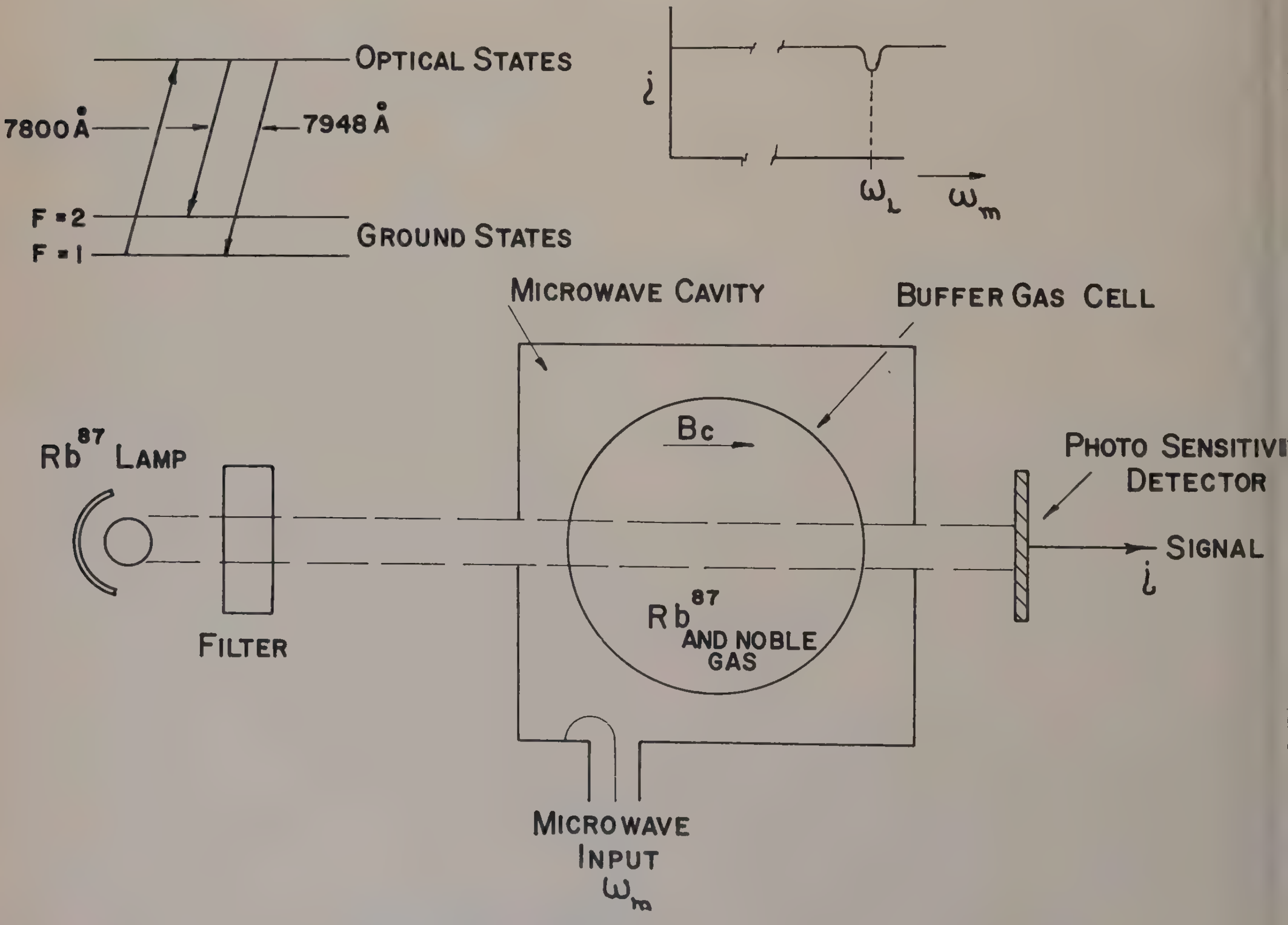
Optical States
7800 Å
7948 Å
F = 2
F = 1
Ground States
i
ω_L
ω_m
Microwave Cavity
Buffer Gas Cell
Bc
Rb 87 Lamp
Filter
Rb 87 and Noble Gas
Photo Sensitiv
Detector
Signal
i
Microwave Input
ω_m

Figure 6 — Rubidium buffer gas cell resonator.

together with a noble gas or a mixture of noble gases. Those rubidium atoms which are within the volume of the cell diffuse relatively slowly through the buffer gas until they reach a wall. Noble gases, being magnetically inert, do not appreciably relax magnetic hyperfine states during collisions with rubidium atoms. Hence the rubidium atoms may interact with a microwave field in a cavity surrounding the cell during the entire diffusion period until the process is ended by a relaxation collision with a wall.

The rubidium atoms are "pumped" into the required energy states by optical radiation from a rubidium lamp. This process, in one of its forms, may be understood by referring to Figure 6, which includes a simplified diagram of the optical transitions in Rb^{87}. Light from the lamp is filtered to remove that portion of the radiation which can be absorbed by atoms in $F=2$ states. Only those Rb atoms within the buffer gas cell which are in $F=1$ states are raised to higher optical states by absorption of the radiation. While the excited optical states relax by radiating to both of the hyperfine levels of the ground state, the net result of the cycle is to increase the population of $F=2$ level at the expense of $F=1$. After the cycle has been repeated several times, essentially all of the Rb^{87} atoms in the cell will find their way to the $F=2$ level. It turns out that they are equally distributed among the magnetic substates and, in particular, there will be atoms in the required $F=2$, $m_F=0$ level while the $F=1$, $m_F=0$ level is depopulated. It has been found[17] that a very effective filter for removing the undesired component of radiation from the Rb^{87} lamp is a cell containing Rb^{85}.

The Rb^{87} buffer gas resonance cell becomes relatively transparent to the pumping radiation when the $F=1$ states have been depopulated. However, the presence of a microwave signal which causes atoms in the $F=2$, $m_F=0$ level to flop into the $F=1$, $m_F=0$ level decreases the transmission of the pumping light due to the added absorption events. This effect is used to detect the resonance of the buffer gas cell to the microwave radiation. As indicated in Figure 6, the pumping light is measured by a photosensitive detector. A decrease in the signal at this detector is evidence of resonance.

The rubidium buffer gas cell resonator makes use of a small, external, uniform magnetic field for the same reasons mentioned for the other resonators.

The collisions between the rubidium atoms and the buffer gas during the diffusion process cause a shift in the resonance frequency due to the fact that, for part of the time, the rubidium atoms are distorted in shape and the magnetic field at the site of the valence electron, which enters into equation (4), is thereby modified. Since the collision frequency is the important factor in this resonance shift, both buffer gas pressure and temperature enter the picture. However, it is possible to compensate the resonance cell for one or the other of these parameters by the use of mixtures of noble gases for the fill. Argon and neon are most common in the devices now available.

The diffusion time in cells of a few centimeters radius is approximately 10^{-2} seconds. The corresponding resonance Q is in the neighborhood of 10^8.

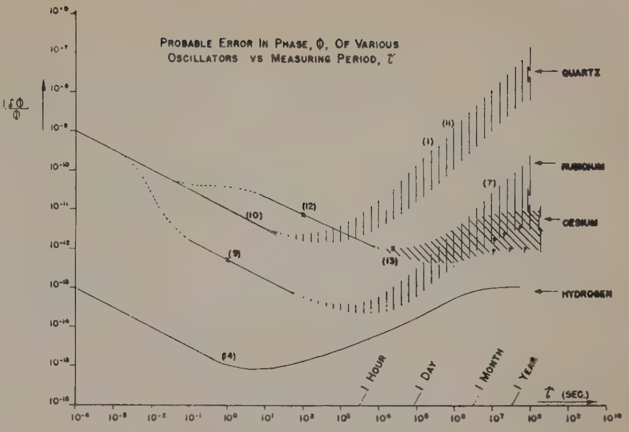

Figure 7 — Magnitude of the probable error, $|\delta\phi|$ in the phase, ϕ, accumulated during the measuring period, τ, for a free quartz oscillator, a rubidium buffered gas cell controlled quartz oscillator, a cesium atomic beam controlled quartz oscillator, and an atomic hydrogen maser. The numbers specify bibliographic references relating to the performance cited, and crosses indicate regions where the results of detailed measurements are available. The curve for the atomic hydrogen maser is based entirely upon calculation in the region of small τ values and estimation in the region of higher τ values.

PERFORMANCE CHARACTERISTICS

The detailed performance of frequency control devices is influenced by the electronic circuits which are part of them as well as by the atomic resonator. A discussion of these circuits is beyond the scope of this paper. However, it is possible to consider some of the performance characteristics which arise due to the resonator properties alone.

Figure 7 consists of a semi-quantitative plot of the stability to be expected for the three resonators and quartz crystals. The abscissa represent measuring periods of length τ during which the total oscillator phase accumulation ϕ is measured. The ordinates are averages of the magnitudes of relative fluctuations, $\frac{\delta\phi}{\phi}$, which would be expected for a group of measurements, each of length τ. In the case of quartz crystals, for small values of τ, the effect of random noise fluctuations within the oscillator limits the stability. Because of the random nature of these fluctuations, the stability in this region[10] improves as $\tau^{1/2}$. For longer measuring periods, the aging effects and drift limit the stability. Thus in the case of the highest quality, well aged quartz oscillators, the drift rates range from 1×10^{-11} to 1×10^{-10} per day.

Both the cesium atomic beam controlled oscillator and the rubidium buffer gas cell controlled oscillator make use of slaved quartz crystal oscillators. For measuring times which are short compared to the response time of the control circuits, these devices must have the same stability characteristics as the quartz oscillators they contain. For longer measuring periods they exhibit the characteristics of the atomic resonators. The transition, represented by dotted lines in Figure 7, from the quartz oscillator characteristic to the atomic resonator characteristic is largely a matter of engineering discretion. However, the response time of the control circuits cannot be faster than that of the atomic resonator; this is approximately the reciprocal of the atomic resonance width.

The cesium atomic beam controlled oscillator, for measuring periods extending from about one second to a few thousand seconds, is limited in stability by the random shot fluctuations in the atomic beam, and in this region a $\tau^{-1/2}$ behavior prevails. While the intensity of the atomic beam may be varied, it is not feasible to reduce the effect of shot fluctuations by much more than a factor of ten below that illustrated.

The long term stability characteristics of the cesium atomic beam are principally influenced by the uniformity of the microwave phase in the interaction structure.[12] Non-random effects such as environmental temperature changes can lead to very small variations in this phase; however, it is reasonable to expect that such limitations will not be encountered for stabilities appreciably less than 1 x 10^{-12} in the case of two meter resonators. Measurements made in several laboratories support this expectation. However, it has not yet been possible to carry out tests over really long periods of time. This circumstance should soon be overcome.

A unique property of the cesium atomic beam resonator is the absence of any known aging effects. The active atoms in this device are exposed to a minimum number of perturbations since there are no collision processes involved in the interaction period.

The rubidium buffer gas cell is characterized by a relatively high signal to noise ratio and consequently it can improve upon the short term stability of the quartz oscillator as indicated in Figure 7. The noise, in this case, arises from the shot effect in the detected photocurrent and its random nature also leads to a $\tau^{-1/2}$ behavior. Because of the frequency shift arising from the diffusion process, there exists the possibility of an aging effect due to buffer gas pressure or composition changes. The best available measurements[7] indicate that such aging is not greater than 1 x 10^{-11} per month as indicated by the upper bound of the fuzzy part of the rubidium curve in Figure 7. The true limitations in this respect, however, await the results of further study.

The atomic hydrogen maser is a new arrival on the scene of atomic frequency standards, and extensive measurements of its performance have not yet been accomplished. In fact, the techniques for making the measurements are just now under development. However, the hydrogen maser, on the basis of the best calculations that can be carried out, appears to have the very high degree of potential performance indicated in Figure 7. For short measuring periods, the stability is characterized by thermal noise in the microwave cavity and, again, should be described by a $\tau^{-1/2}$ law. For the long measuring periods, several effects appear to become important[18] and the limit of stability may be in the region of 1 x 10^{-13}. These effects include the thermal stability of the microwave cavity, the doppler effect which is influenced by the temperature of the atomic hydrogen source, and, most uncertain, frequency shift due to wall collisions. It is conceivable that aging of the walls might influence such a collision shift; however, the indications which are available, although scanty, are very promising. Small inhomogeneities in the steady magnetic field in the transition region must be reduced to a very great extent in order to avoid certain transitions due to the resulting time-varying magnetic fields which are experienced by the excited atoms on account of their motion. Such effects become important in the case of the atomic hydrogen maser because of its very high degree of stability.

Some of the important properties of resonators cannot be expressed in a diagram such as Figure 7. In addition to stability over various periods of time, for example, the reproducibility of the resonator is an essential characteristic. In a somewhat restricted sense, good reproducibility follows from a high degree of long term stability, particularly if the manufacturing process permits adjustments. In a more general sense, however, the *intrinsic reproducibility* is an independent characteristic which reflects the ability of the resonator to operate at a frequency which is related in a precisely known way to the unperturbed natural atomic frequency. A high degree of intrinsic reproducibility implies that calibration procedures involving adjustment of frequency against primary standards are not required. The statistical scatter in frequencies of units constructed at any time or place by following a given set of instructions and using commonly accepted tolerances for measuring lengths, pressures, electrical quantities, etc. is the quality factor involved in this connection.

A long interaction time, T_f, leading to high resonance sharpness, is important to intrinsic reproducibility, particularly with respect to problems arising from microwave cavity detuning or phase shifts in microwave fields. For this reason, the hydrogen maser appears to have a very great potential in this regard. The magnitude of wall collision shifts and their specific reproducibility will, of course, bear upon the question.

The cesium atomic beam resonator has a degree of intrinsic reproducibility which is about equivalent to the long term stability. This arises from the fact that the quantum mechanical processes are influenced by a minimum number of perturbations which include just the homogeneous magnetic field, B_c, and the microwave field. While the phase of the microwave field enters the problem, methods have been devised[12] to assure that it conforms to requirements.

The buffer gas cell resonator must be calibrated during manufacture and the pressure of the buffer gas is adjusted to establish resonance frequency within close limits. However, this procedure does not limit the application of this device to problems which require secondary standards since, once set, the frequency may remain within required limits.

Another group of resonator properties which are of interest include size and weight factors. At the present time, the buffer gas cell is clearly the most compact and it has high intrinsic ruggedness. The cesium resonator, because of its nature, must have one long dimension and its weight is influenced by the use of magnetic state selection. The position of the hydrogen maser in this connection awaits its further development, and the outlook in this case is favorable.

CONCLUSION

No discussion of atomic frequency control seems complete without some mention of applications. Atomic deces are already in use as frequency standards maintained y various governments, and this application is sure to ncrease. In the near future they will become essential to ew communication systems. The increased use of microwave frequencies as the result of earth satellite developments and the concomitant need for microwave spectrum onservation will require the long term stability characteristics of these devices. This is particularly true of ingle side band transmissions at microwave frequencies, or which transmitter exciters and receiver local oscillators must always be within a few cycles of their nominal requencies in order to avoid distortion. While quartz rystals have been adequate for such work at lower frequencies, the microwave case will require atomic resonator controlled oscillators.

The high degree of short term stability, or spectral purity of rubidium buffer gas cell oscillators, and to an even greater extent, atomic hydrogen masers, will be essential to communication systems which handle very low data rates. Such systems, which are becoming important for deep space probes, require transmitter exciters and receiver local oscillators having noise spectra narrow compared to the condensed modulation spectra which are characteristic of this problem.

Finally, atomic clocks for keeping time accurately for long periods in a wide variety of applications are becoming important. These applications include navigation problems of several types, missile range instrumentation, and synchronized world wide networks of time keepers essential to modern technical developments.

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FERRIMAGNETIC LIMITERS*

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Introduction

Only within the past year have technological advances made it practical to utilize ferrimagnetic limiters in microwave systems. Limiters have been built which protect crystals and varactors against burnout due to high power. These limiters can be built so that they exhibit negligible spike leakage. They are completely passive and in normal service should have essentially no lifetime limitations. They can be built to satisfy broadband requirements or in the case of some gyromagnetic coupling limiters, they will exhibit preselector characteristics as well as low level limiting. As a result, the utilization of ferrimagnetic limiters in microwave systems should be greatly enhanced.

It has been known since the works of Damon, Bloembergen and Wang[1,2,3] that ferrimagnetic materials exhibit nonlinear properties. They found among other things, that if a sample of ferrite or garnet in a microwave transmission system is subjected to power above a certain threshold level, a subsidiary resonance peak will appear for a value of dc magnetic field some hundreds of oersteds smaller than that required for the main ferrimagnetic resonance absorption.

Since that time considerable effort has been focused on the development of a ferrimagnetic microwave power limiter. A microwave system in which TR tubes have been replaced by ferrimagnetic limiters will be a greatly improved system, particularly from the standpoint of reliability.

The realization of a practical ferrimagnetic diode protector required the solution of two formidable problems — (1) a limiting threshold which is sufficiently low to protect the diode from burnout or long term deterioration by a cw signal and (2) the reduction or elimination of leakage energy in the leading edge spike of a limited pulse.

There are two types of nonlinearities associated with the equation of motion of the spin waves which can be utilized to build a microwave power limiter. The first effect manifests itself in the form of a subsidiary resonance which absorbs power above a certain critical microwave field intensity (h_c). The subsidiary absorption, if it is present at all, will appear at a value of dc magnetic field which is usually about half of that normally required for main ferrimagnetic resonance. Provided that the length of the ferrimagnetic medium is sufficient, the absorpti due to the subsidiary resonance will increase with incre ing power input above h_c and the power out of the limit above h_c will usually remain essentially constant.

The second phenomenon is associated with a decline the susceptibility of the uniform precessional resonan above a critical power level.

Theoretical Principles of Ferrimagnetic Limiters

In order to gain a better understanding of the nonline phenomena it is necessary to review the spin wave theor as outlined by Suhl.[4] These spin waves, which result fro the slightly out of phase precession of adjacent magnetiz tion vectors, are always present to some extent in a ferr magnetic medium. There are an infinite number of sp waves, and it has been shown that for an ellipsoid, the waves will lie within definite frequency boundaries shown in Figure 1 and are defined by the following equ tion:

$$\omega^2_k = (\omega_H - \omega_m N_z + \omega_{ex} l^2 k^2)(\omega_H - \omega_m N_z + \omega_{ex} l^2 k^2 + \omega_m \sin\sigma_k), \qquad (1$$

where

ω_k = spin wave frequency,
$k = \frac{2\pi}{\lambda_k}$ spin wave number,
λ_k = distance between adjacent in phase spin
$\omega_H = \gamma H$,
$\omega_m = \gamma 4\pi M_s$,
N_z = demagnetizing factor parallel to dc fiel
$\omega_{ex} = \gamma H_{ex}$, where H_{ex} = internal exchange field ($H_{ex} \approx 10^6$ gauss),

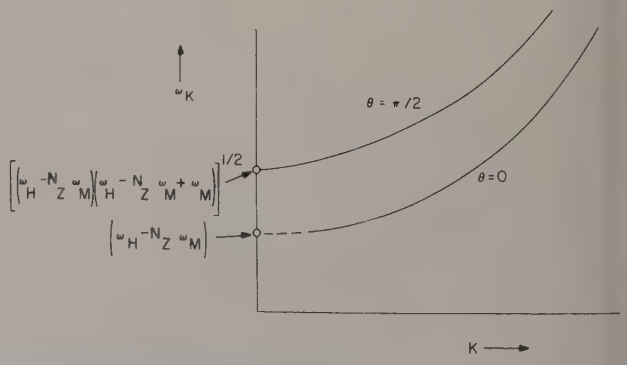

Figure 1 — Spectrum of spin waves for a spheroid.

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σ_k=angle between dc field and k,

1=lattice constant.

Suhl has written the equation of motion of the spin waves and has derived an expression, which follows, for e level of the microwave magnetic field which will cause stabilities in the precessional motion.

$$h_{crit}=\frac{2\omega_k\left\{\left[\left(\gamma\Delta H_k\right)^2+\left(\frac{\omega}{2}-\omega_k\right)^2\right]\left[\left(\gamma\Delta H\right)^2+\left(\omega-\omega_{res}\right)^2\right]\right\}^{1/2}}{\gamma\omega_m \sin\sigma_k \cos\sigma_k\left[\omega_k+\omega_H-\omega_m N_z+\omega_{ex} 1^2k^2\right]} \qquad (2)$$

here

ΔH=conventional uniform precessional linewidth,

ΔH_k="spin wave linewidth."

The subsidiary resonance limiter is derived by biasing he ferrimagnetic medium to what would be resonance at pproximately $\frac{\omega}{2}$. If $\frac{\omega}{2}$ is within the spin wave specum for this applied field, then

$$\frac{\omega}{2}=\omega_k \qquad (3)$$

or some k. Equation 2 is now minimized subject to quation 3. The minimization requires that σ_k be some ntermediate angle between 0 and $\frac{\pi}{2}$ (near $\frac{\pi}{4}$) and sually requires that k=0.

Then for $(\omega-\omega_{res})^2>>(\gamma\Delta H)^2$

$$h_c\approx\frac{\omega\Delta H_k\,(\omega-\omega_{res})}{\omega_m\left[\frac{\omega}{2}+\omega_H-\omega_m N_z\right]}. \qquad (4)$$

f the above conditions are satisfied and if the power level s sufficient to make $h>h_c$ in Equation 4, a subsidiary bsorption peak will appear at a value of applied dc field which is usually about half of that required for resonance. As the power is increased above h_c, the absorption in the ubsidiary resonance will increase and the power output will remain essentially constant. The ratio of low power oss to high power loss depends upon many things, some of which will be discussed later.

The second type of limiter (decline of the main resonance susceptibility) will take the form of a gyromagnetic coupler where essentially all of the microwave power below h_c is coupled through a narrow linewidth ferrimagnetic medium which is biased to resonance. The microwave structure of the gyromagnetic coupler can take the form of orthogonal strip transmission line cavities, crossed waveguides or even parallel waveguides, or orthogonal coupling loops with a polished yttrium-iron garnet sphere at a point of maximum microwave magnetic field between the two "transmission lines." The precessing magnetic moments couple energy from one system to the other with low loss for input power below h_c.

In this case the ferrimagnetic medium is biased to resonance; $\omega_{res}=\omega$. Equation 2 can be solved in terms of certain conditions of $4\pi M_s$, geometry and frequency for h_c at resonance. The solution, depending upon conditions, will be either of the following:[5]

$$h_c\approx\frac{\Delta H\,\Delta H_k}{8\pi M_s}, \qquad (5)$$

$$h_c=\frac{\Delta H}{2}\sqrt{\frac{\Delta H_k}{4\pi M_s}}. \qquad (6)$$

Equations 5 and 6 apply for a circularly polarized driving microwave field. If the resonant medium is axially symmetrical about the direction of the applied dc magnetic field, then

$$\omega_{res}<2\,N_T\,\omega_m \qquad (7)$$

will guarantee that Equation 5 applies, and if the inequality is reversed, Equation 6 applies. The frequency at which $\omega_{res}=2\,N_T\omega_m$ is sometimes called the critical frequency f_c. As an example a sphere of yttrium-iron garnet operating below 3300 mc would satisfy Equation 7, and hence, Equation 5 applies. Saturation requires that the sphere be above $\omega_{sat}=\gamma N_z\,4\pi M_s\approx1650$ mc. Above 3300 mc Equation 6 applies.

When the microwave magnetic field exceeds h_c, the susceptibility of the ferrimagnetic medium declines in one of two ways. At frequencies below f_c and above ω_{sat},

$$\frac{X''(h>h_c)}{X''_o}=\sqrt{\frac{P_{crit}}{P}}, \qquad (8)$$

where

X''_o=susceptibility at infinitesimal applied power,

P=incident power,

P_{crit}=approximate power level at which susceptibility begins to decline.

At frequencies above f_c[6]

$$\frac{X''\,(h>h_c)}{X''_o}=\frac{1}{\sqrt{2}}\left(\frac{P_{crit}}{P}\right)\left\{\left[1+4\left(\frac{P}{P_{crit}}\right)^2\right]^{1/2}-1\right\}^{1/2} \qquad (9)$$

The shapes of Equations 8 and 9 are shown in Figure 2.

Experimental Design Principles

A. Subsidiary Resonance Limiters

The realization of a practical subsidiary resonance ferrimagnetic diode protector will require an h_c corresponding to a power input of just a few milliwatts. It can be seen in Equation 4 that for the materials available today the lowest h_c that one might expect at 5 kMc is around 2 oe. ($\Delta H_k\approx$2oe). In full size C-band waveguide with no dielectric perturbation of the fields this corresponds to a microwave power of about 2000 watts. To attain this threshold, and to eventually go considerably below it, an optimum geometry, microwave structure, and dielectric effect must be derived.

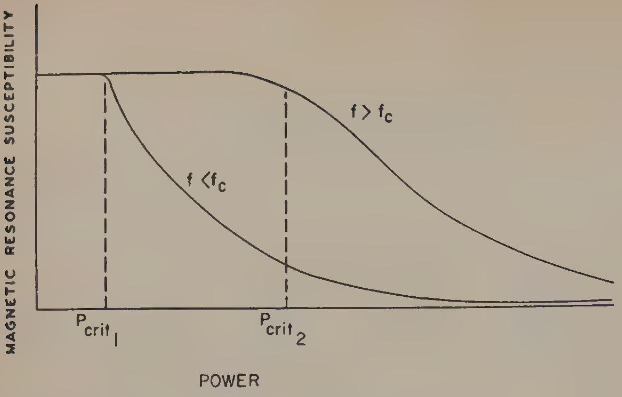


Figure 2 — Susceptibility as a function of power for frequencies above and below the critical frequency.

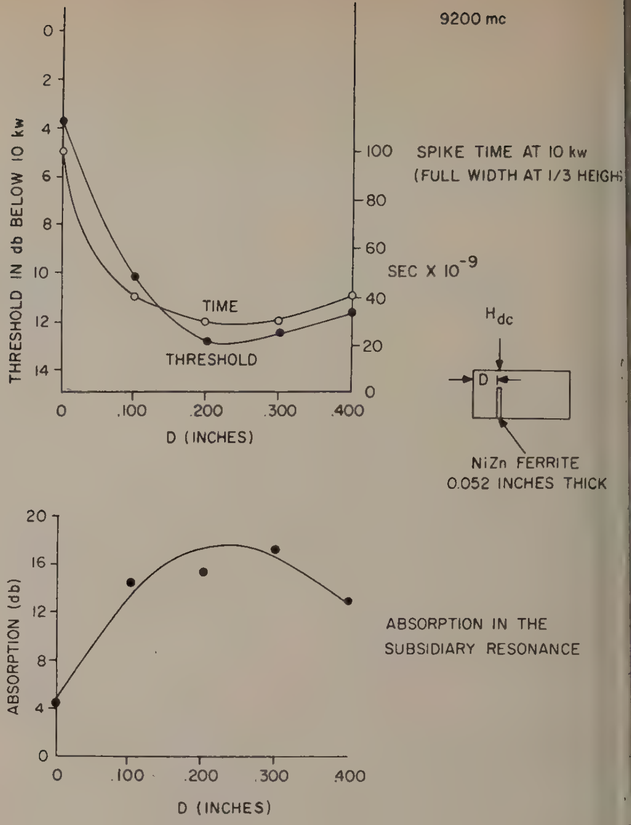
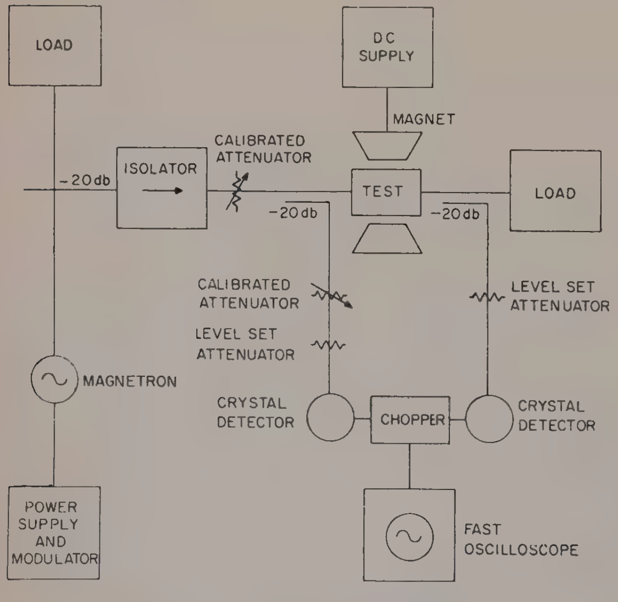


Figure 4 — Position study.

In studying these parameters, measurements were performed in X- and C-bands using both rectangular and double ridge waveguide. The experimental apparatus is shown in Figure 3.

It was quickly determined after trying both vertical and horizontal slabs in the waveguide that vertical slabs magnetized vertically resulted in a far lower threshold (this result agrees with other parts of Suhl's theory not discussed here). The slab was then moved to various positions across the width of the waveguide. At each position measurements were made of threshold, absorption in the subsidiary resonance, and spike time. The spike will be discussed later. Figure 4 depicts the results.

It is seen that the optimum position across the guide corresponds approximately to the position of circular polarization. The conditions of circular polarization were then established between the ridges of DR-34 waveguide in C-band by the use of dielectric. The concentration of microwave energy on the ridges and in the dielectric served to further lower the threshold. A by-product of the circularly polarized wave in the garnet is non-reciprocal attenuation in the limiter.[7] A limiter-isolator is a device which will pass low or high power signals in one direction of transmission with very low loss, but in the other direction will pass unattenuated only those signals which are below the threshold level of the limiter-isolator and wi absorb all power above that level. It could therefore b used in the antenna arm of a duplexer where it woul serve the dual purpose of attenuating all signals above


LOAD
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TEST
LOAD
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LEVEL SET
ATTENUATOR
LEVEL SET
ATTENUATOR
MAGNETRON
CRYSTAL
DETECTOR
CHOPPER
CRYSTAL
DETECTOR
POWER
SUPPLY
AND
MODULATOR
FAST
OSCILLOSCOPE

Figure 3 — Experimental apparatus.

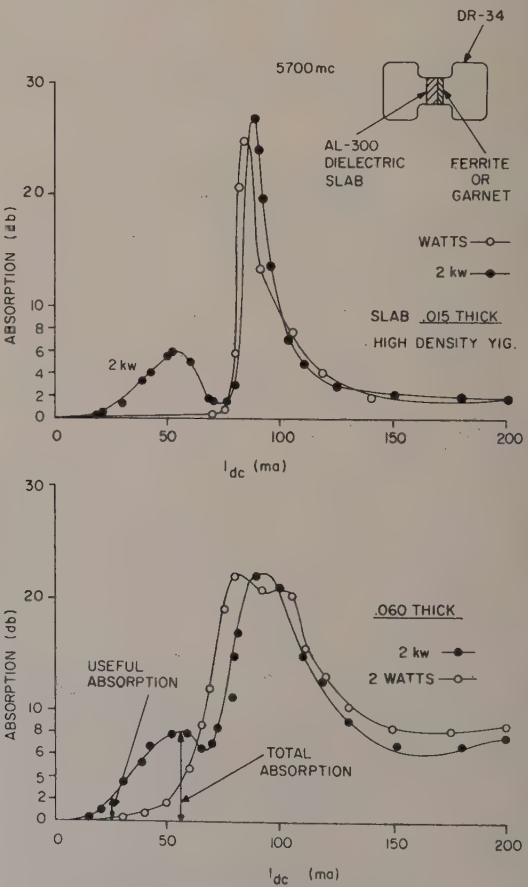
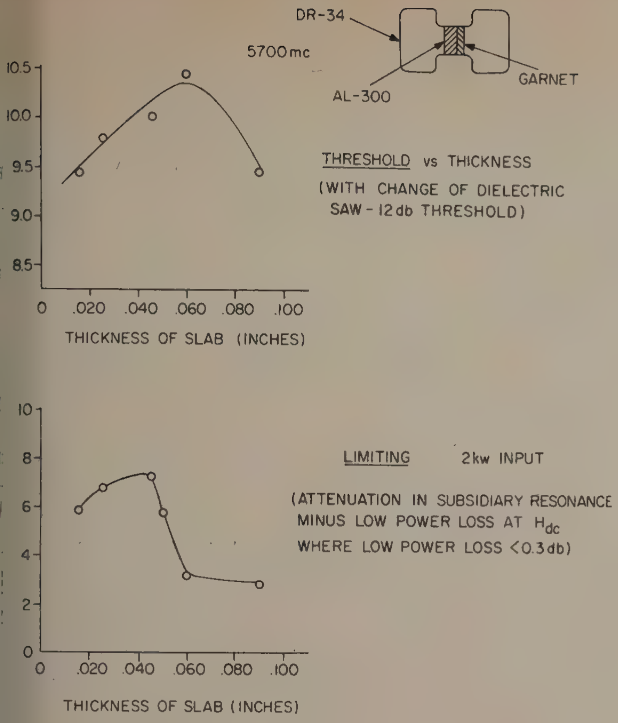


Figure 5 — Thickness study.



igure 6 — Threshold and limiting as a function of slab thickness.

hreshold level which are reflected from the antenna due to 'SWR, or suppressing high power signals which might e received from a nearby interfering station.

Slabs of garnet of various thicknesses were then tried in n effort to optimize geometry. Figure 5 shows results rom two particular slabs. Figure 6 shows the threshold nd useful absorption for several thicknesses. The maerial used was yttrium-iron garnet. It can be seen that he thicker slabs generally result in lower thresholds and nore total absorption in the subsidiary resonance. However, when useful absorption is considered (attenuation in he subsidiary resonance at high power, minus the low ower loss at a dc field taken where the low power loss is ess than 0.3 db) it can be seen that the optimum thickess is somewhat less than that which gives the lowest hreshold. It would therefore be necessary in a device at his frequency to sacrifice the lowest threshold for an aceptable insertion loss.

Figure 7 is a reproduction of photographs of an oscillocope trace which show simultaneously the pulse into the imiter and the pulse out of the limiter at three power evels. The leading edge spike is plainly visible.

This spike is a result of the time delay during which the ppropriate spin wave frequencies receive their excitaion from the uniform precessional mode and dissipate he converted energy as heat in the lattice. The delay is a unction of material parameters ($\triangle H_k$) and the magniude of power above the limiting threshold. Figure 8 depicts the energy conversion processes and their associated times. These times are related to linewidth by the following equation:[8]

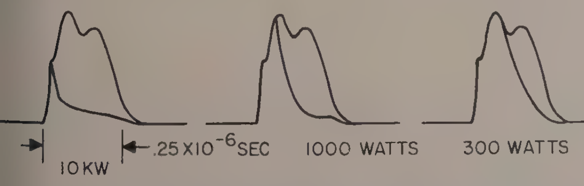
$$\triangle H = \frac{1}{\gamma}\left(\frac{1}{T_{10}} + \sum_{k} \frac{1}{T_{2k}}\right), \tag{10}$$

$$\triangle H_k = \frac{1}{T_{1k}} .$$

If $\triangle H_k$ is increased in an effort to shorten the spike time, the result will be an increase in the limiting threshold. In a single stage limiter it is therefore necessary to choose between a low threshold and a large spike or a higher threshold and less spike (assuming that dielectric perturbation is the same in any case).

A subsidiary resonance limiter of the type discussed here will have an appearance very similar to an isolator. Bandwidth of the limiters should approximate that obtainable with an isolator built in the same type of structure. Limiters have been built in our laboratory in rectangular waveguide, double ridge waveguide and coaxial transmission line. All of these structures will perform similarly when properly loaded with dielectric. The proper loading is that which will result in a strong h_{rf} in the ferrimagnetic material.

A technique originated by Stern[9] results in a very strong h_{rf} in the ferrimagnetic material. The limiter uses a circulator in which energy is transferred from Port 1 to Port 2 and Port 2 to Port 3. A shorted arm is placed on Port 2. A full height rod of garnet to ferrite is placed in the shorted arm at a point so that the short will reflect a current maximum and hence an h_{rf} maximum to the material. A small longitudinal hole is drilled out of the rod and a small wire is inserted through the hole. The wire is bonded to the top and the bottom of the guide. The strong currents set up at the rod are then conducted by the wire and a strong circular h_{rf} is set up in the material. Figure 9 shows the device and data obtained in our



igure 7 — Oscilloscope tracings of a microwave pulse before and after limiting at three power levels. Vertical gain of oscilloscope amplifier was changed between power levels.

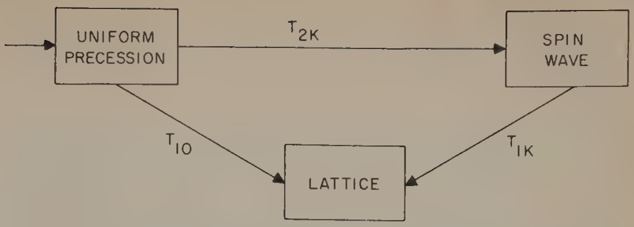


Figure 8 — Energy conversion process showing two routes to the lattice (after Fletcher, LeCraw and Spencer[6]).

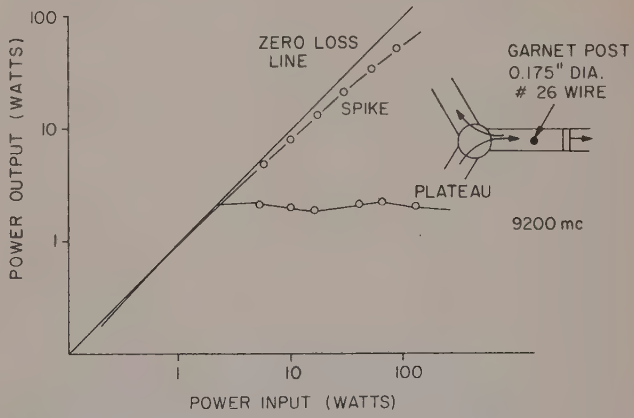


Figure 9 — Fine wire limiter.

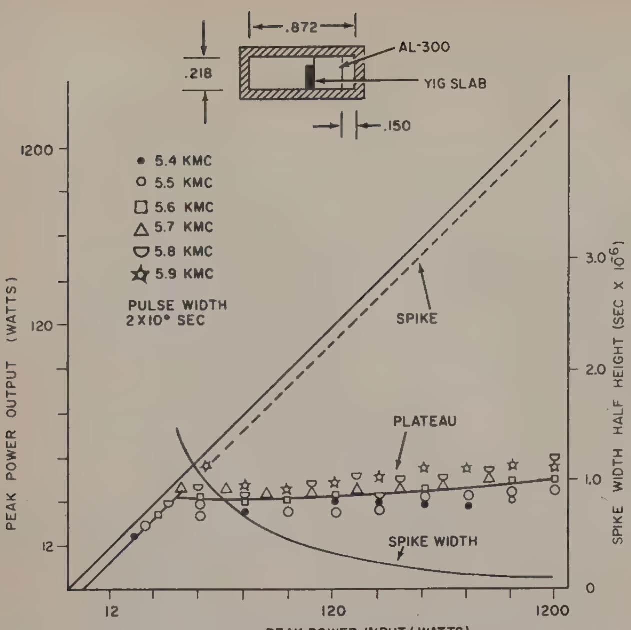


Figure 10 — Limiting characteristics of a wide band subsidiary resonance limiter.

laboratory on a model operating in X-band. Other subsidiary resonance limiters which make use of field concentration techniques are shown in Figures 10 and 11.

B. *Gyromagnetic Coupler Limiter*

A limiter of this type was first built by DeGrasse.[10] He used two orthogonal strip line cavities and coupled energy from one cavity to the other through a highly polished single crystal yttrium-iron garnet sphere.

Earlier comments in this paper indicated that several structures other than the one described by DeGrasse will satisfy the necessary microwave conditions that will lead to a working gyromagnetic coupler limiter (GCL). Carter[11] has described some structures and derived expressions relating to coupling. Most of these structures have been investigated and found to perform as expected.

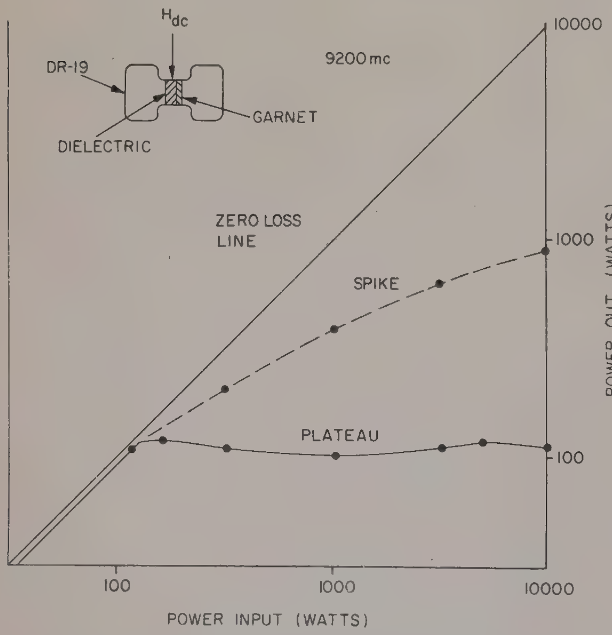


Figure 11 — A typical double ridge waveguide subsidiary resonance limiter. This model is non-reciprocal.

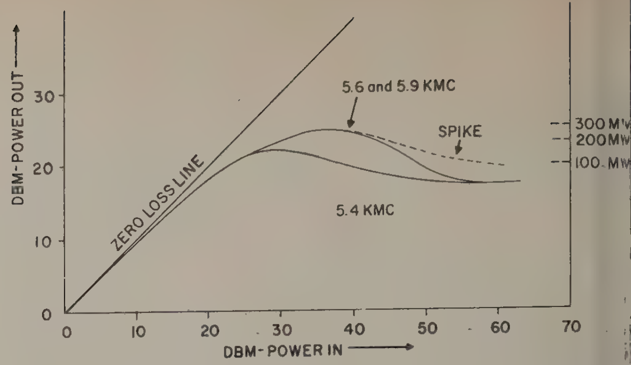


Figure 12 — Gyromagnetic coupler limiter operating in C-ban (Courtesy of J. Clark).

The basic design of a GCL requires a low loss gyromag netic coupling medium. It has been found experimental that at C-band a linewidth of less than 0.5 oersteds is re quired before low loss coupling can be achieved. In add tion, it is required that there be very little leakage from one "transmission line" to the other in the absence of resonating field on the coupling medium. The dynam operating range of the limiter is dependent upon th leakage. If leakage power is down by, say, 20 db (that i a difference in coupling of 20 db between the resonan and non-resonant power transfer below the threshold then the dynamic range of the limiter can be no more tha 20 db. The leakage is usually minimized by coupling be tween orthogonal microwave fields with a resonant YI sphere at a position of maximum, linear, microwave mag netic field.

The data to be presented here were taken from gyro magnetic coupling limiters in S-band and C-band. I each instance the coupling medium was highly polishe resonant, YIG. Equation 7 indicates that the critical fre quency (f_c) for YIG spheres is about 3300 mc, so tha in S-band the sphere is resonant below f_c and at C-band is resonant above f_c. The data obtained from these limite are interestingly different. Figures 12 and 13 show th results. Note in particular that the C-band model ha negligible spike leakage. The limiting characteristics ob tained at C-band would be observed at higher frequencie and could also be observed at lower frequencies, provide that f_c is lowered. This can be accomplished by a chang in the geometry of the coupling medium or by lowerin the $4\pi M_s$ of the medium. Equations 6 and 9 apply to th C-band model in Figure 12, and Equations 5 and 8 appl to the S-band model in Figure 13 (see also Figure 2).

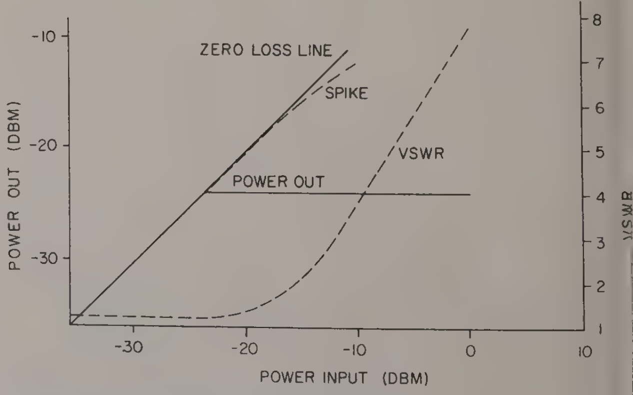


Figure 13 — Gyromagnetic coupler limiter operating in S-ban (typical).

It has been found that with all other parameters con-ant, h_c is directly proportional to the sphere volume.

xperimental Performance

The threshold and power dissipating capacity of sub-diary resonance limiters make them suitable for use as rst stage limiters or possibly in some cases as a single age protective limiter. In an experiment performed in ur laboratory at C-band, a parametric amplifier was pro-cted by a coaxial subsidiary resonance limiter. The ower input to the limiter was 1000 watts peak (.0015 uty cycle). Its characteristics are similar to those shown n Figure 11. Unfortunately, no data are available which ill indicate the lifetime of the diode when operating ontinuously as described here. The power leakage through subsidiary resonance limiter (with the possible excep-on of the fine wire limiter) is too great to be at a safe vel for a crystal detector or mixer.

A C-band model[12] of a GCL was used to protect a 1N23 ystal detector. The power input to the limiter was ised from milliwatts in small steps to about 8 kw, and e detected waveform of the crystal was monitored. Sev-al crystals were selected at random and tested in this shion. They all performed essentially the same, and owed no adverse effects. The duty cycle of the incident ower was 0.001.

Another experiment of interest involved a two stage miter. The subsidiary resonance limiter of Figure 10 as used as the first stage limiter and the GCL of Figure 2 was the second stage limiter. The combination was sub-cted to a peak power of 25 kw. A flat leakage power of 25 milliwatts and a total spike leakage of 0.2 to 0.3 erg as measured. The spike amplitude was of the order of .5 watt. The total insertion loss, which could certainly e reduced with additional effort, was slightly in excess of db. Neither the limiter nor the crystal detector showed ny degradation of performance at the maximum power vailable (25 kw).

ummary

This paper reviews in brief the nonlinear theory of errimagnetism at high signal power levels. It describes ome experimental design principles in the building of miters which can be outlined as follows:

1. *Subsidiary resonance*
   a) Select a ferrimagnetic material which will result in a low threshold — low $\triangle H_k$, high $4\pi M_s$.
   b) Use various techniques which will further lower the threshold by concentration of microwave magnetic fields in the material.
   c) Experimentally determine the best geometry for bandwidth and loss considerations.
2. *Gyromagnetic coupler*
   a) Use a low linewidth (0.5 oersted) ferrimagnetic coupling material.
   b) Arrange the microwave structure so that there is very little leakage from one transmission line to the other exclusive of gyromagnetic coupling.
   c) Arrange the geometry and $4\pi M_s$ of the gyromagnetic coupling medium so that the operating frequency is above f_c.

A passive subsidiary resonance limiter when operating in normal fashion will always have considerable spike leakage, but when it is followed by a GCL operating above f_c, the result is a passive ferrimagnetic limiter which affords completely adequate crystal protection.

Acknowledgment

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RF LEAKAGE CHARACTERISTICS OF POPULAR COAXIAL CABLES AND CONNECTORS, 500 MC TO 7.5 GC.

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Introduction

In the design and use of coaxial devices, a knowledge of the leakage characteristics of radio-frequency cables and connectors is important, both in measurements and in the design of operational and test equipment.

The evaluation and measurement of electromagnetic leakage through solid conductors, braids, screens, slits and other configurations employed to confine the electromagnetic fields in apparatus, has been the subject of a great deal of analysis and research. Some investigators have been concerned with the leakage phenomenon itself,[1,2,3,4,5] others with its measurement [6,7,8,9,10,11]. The experimental procedure employed is usually chosen in accordance with the particular manifestation of the electromagnetic leakage that is of interest. For example, for conducted leakage or coupling, a special direct metallic connection may be made between the leakage source and the detector; for induction or near-field leakage, probes or loops are placed in proximity with the leakage source; and, for radiated leakage, probes, loops, or the more distributed version of these, antennas, are placed at what is considered the far field of the leakage source. The three are commonly evaluated, *in toto,* by surrounding the leakage source with a closed coaxial system. The usual practice is to couple some of the basic leakage modes to the TEM mode of the coaxial system.

Usually the equipment designer is successful in confining stray electromagnetic fields within the equipment package except, of course, in open systems such as slotted lines. However, the connection of coaxial cables, flexible and solid, and coaxial components to the equipment introduces a source of leakage. In the case of immittance bridges, cable or connector leakage introduces a spurious signal path between the source and the detector, usually resulting in measurement errors. Leakage is a cause of error in precision slotted-line measurements through spurious coupling of the pick-up probe to the source; in attenuation measurements and filter-response measurements, by spurious coupling between the input and the outp circuits. In complex electronic systems, as for example a missile system, the spurious coupling between the int connecting cables of the separate systems can result malfunction in the operation of an element of the syste

It is the purpose of this paper to demonstrate the re tive shielding effectiveness of popular flexible cables a connectors, and to describe the measurement techniq Test results are presented in terms of both relative leaka power and surface transfer impedance. The unique f ture of this work is the frequency range of measureme The majority of previous contributions were concern with the frequency range below 500 Mc.

Measurement Technique

The measurement of the leakage from connectors a cables is performed by collecting the leakage energy in coaxial system surrounding the leakage source. An o line of the instrumentation is shown in Figures 1 and respectively, and a photograph in Figure 3. The dev from which leakage is to be measured, connector or cab is incorporated in a uniform transmission line which terminated in a matched load. The matched terminati simplifies both the measurement procedure and data duction. This complete coaxial system is embodied with a cylinder which forms, externally, a second coaxial syste The second coaxial system is terminated at one end in adjustable short-circuiting plunger and at the other in

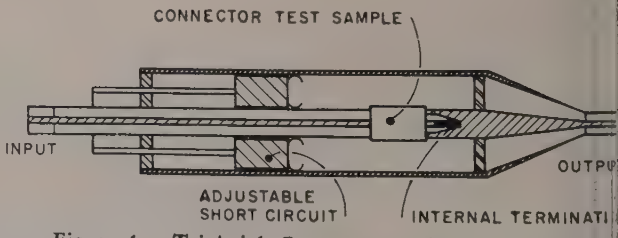

Figure 1 — Tri-Axial Connector Leakage Test Unit.

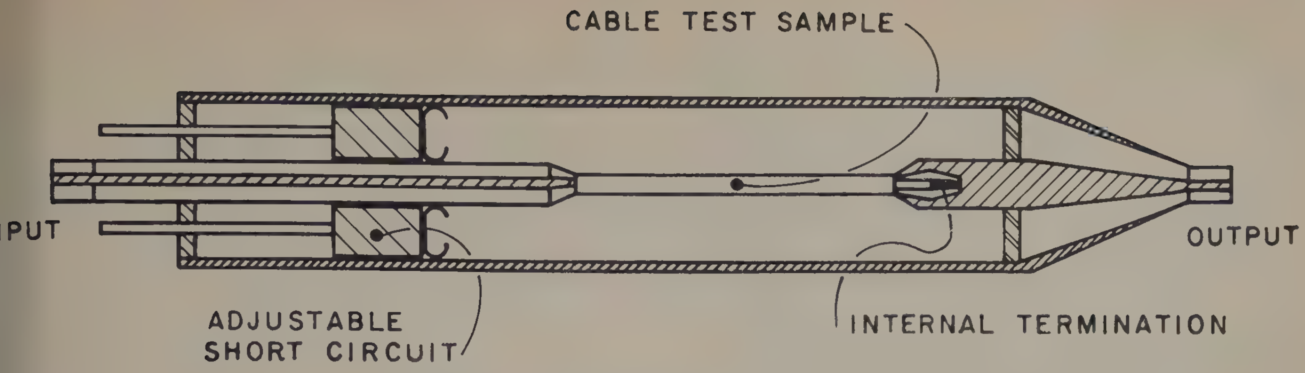

Figure 2 — Tri-Axial Cable Leakage Test Unit.

pered transition to a standard connector. In connector easurements, the outer coaxial line is terminated in a atched detector. Except for the adjustable short-circuit ature, this tri-axial system has been employed by hers.[6,7,8]

For direct leakage measurements the adjustable short cuit serves several purposes both in connector and ble measurements. In connector measurements, the ort-circuit position is adjusted to assure that an ade- ately low impedance appears behind the equivalent kage generator. A matched termination can be substi- ted, but the resulting 6-db loss cannot be tolerated in me cases. In addition, if the leakage source is directional, it indeed is for cables and connectors with multiple kage, it is possible for the leakage to be directed to this rmination at some frequencies and not collected by the tector. For surface transfer-impedance measurements cables or connectors with leakage from more than one int in the connector, however, a matched termination is sirable in order to simplify the transformation of the easured data to transfer impedance data. This latter con- leration is discussed at greater length in the Appendix.

The equivalent leakage generator, in general, can have ld components in the radial, axial, and circumferential* directions. Furthermore, these components are not necessarily circularly symmetric. Locally, TE, TM, and TEM modes can all exist, and in fact, for complete leakage measurements, the detector should couple to all. The excitation of the outer coaxial line, however, is believed to be principally TEM, since the currents in the internal line are predominantly axial and symmetric. In the particular test configuration employed here, only the TE_{11} mode can be propagated, and this only above 3.5 Gc. In the transition to the smaller coaxial line, the TE_{11} mode is filtered out, but some of it couples to the principal TEM mode, delivering this power to the detector. Special care is taken to assure that the test cable or connector system is mounted concentrically, to minimize TE_{11} mode generation.

Despite the possible limitations cited above, the tri-axial system is a simple and effective system for measuring the net leakage. It is indeed well suited for axial surface transfer-impedance measurements. It can serve as a standard method only, however, if the leakage characteristics or axial surface transfer impedance of axially symmetrical components are to be evaluated. Accurate measurement of each mode of leakage, each manifestation of leakage, and each component of surface impedance will, in general, require a specific test configuration for the particular measurement.

The characteristic impedance of the outer coaxial line of the tri-axial system, which is formed with the cable

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The circumferential E-field component is not usually present in axially symmetric components. See References 1, 2.

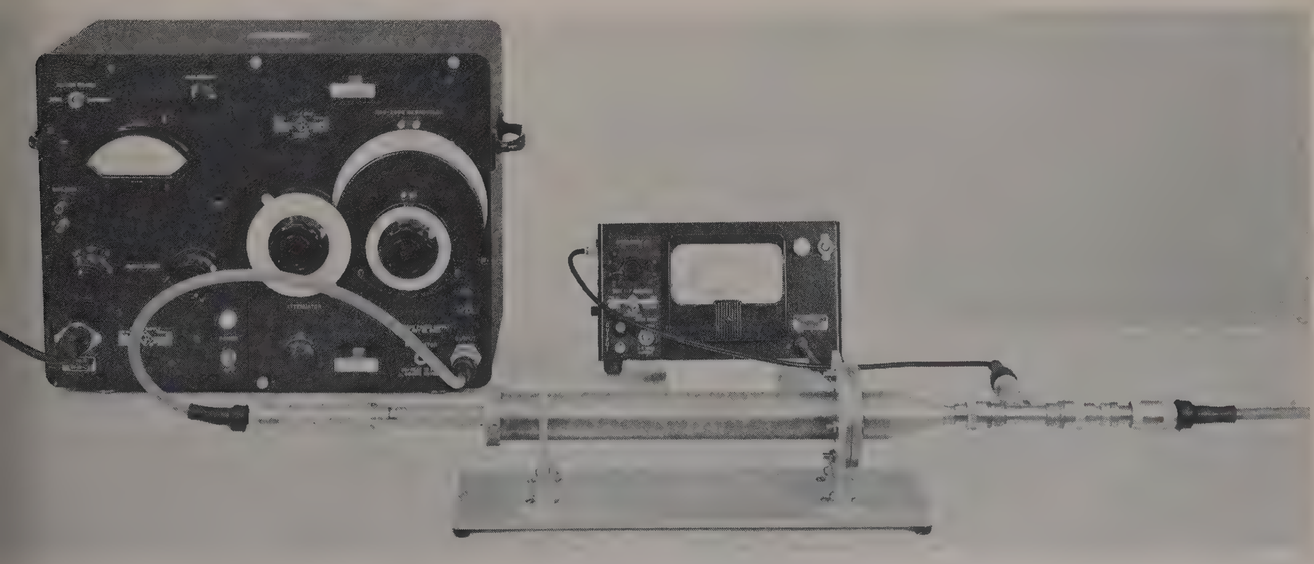

Figure 3 — Tri-Axial Unit and Equipment Setup.

braid as the inner conductor, should be matched to the detector. As a matter of convenience, but with some sacrifice in accuracy and ease of data reduction, one outer conductor size was employed for all cables. The characteristic impedance was therefore generally higher than 50 ohms. The steps in conductor size at the cable connectors also produce capacitance discontinuities. These can be measured or calculated[12]. The effects of the characteristic impedance discontinuity are described in the Appendix.

The leakage power ratio is defined here as the ratio of the power detected in a 50-ohm detector at the output of the tri-axial unit to the power flowing through the internal 50-ohm connector or cable system. It is basically the attenuation through the tri-axial system. This definition appears arbitrary in the sense that 50 ohms is an arbitrary load impedance. However, since the leakage source impedance is comparatively low, the voltage at the detector is essentially the open-circuit leakage voltage. The ratio of the input voltage to the leaky cable, to this output voltage is an absolute leakage quantity, as is the measured power ratio, which is identically equal to the square of this voltage ratio.

The surface transfer impedance is obtained from this ratio as follows:

The surface transfer impedance is,

$$Z_{21} = \frac{e_2}{i_1} \qquad (1)$$

where

i_1 = Current flowing in internal line.
e_2 = Equivalent leakage voltage in external line.

In the connector leakage case, considering the equivalent leakage generator to be e_2 with an extremely low source impedance, this voltage e_2 appears at detector terminals, and the adjustable short circuit assures this. For a 50-ohm transmission-line system, the input power is,

$$50\,i_1^2$$

The measured output power is,

$$\frac{e_2^2}{50}$$

The measured power ratio A^2 is therefore,

$$A^2 = \frac{\frac{e_2^2}{50}}{50\,i_1^2} = \frac{e_2^2}{(50)^2 i_1^2}$$

Substituting and by definition,

$$Z_{21} = \frac{e_2}{i_1} = 50\,A$$

In the cable leakage case, the calculation is not straightforward, especially where the outer tri-axial line not terminated in its characteristic impedance. The culations required to reduce the measured results gi in this paper to transfer impedance per unit length are included for that reason. The tri-axial system was set principally to assess the relative leakage.

For the measurement of surface transfer impedance cables, the outer coaxial line of the tri-axial system sho be terminated in its characteristic impedance at the sou end and in a similarly matched detector at the output In this case the relation between the measured leak power ratio, A^2, and the surface transfer impedance unit length is, in a 50-ohm system,

$$Z_{21} = \frac{100\,A\,(\beta-\beta_o)}{1-e^{-j(\beta-\beta_o)L}}$$

where

L = length of leaky cable section.
β = propagation constant in the test cab
β_o = propagation constant in external line tri-axial system.

This expression is obtained from Equation (5) in Appendix which describes the forward TEM wave launc by the cable.

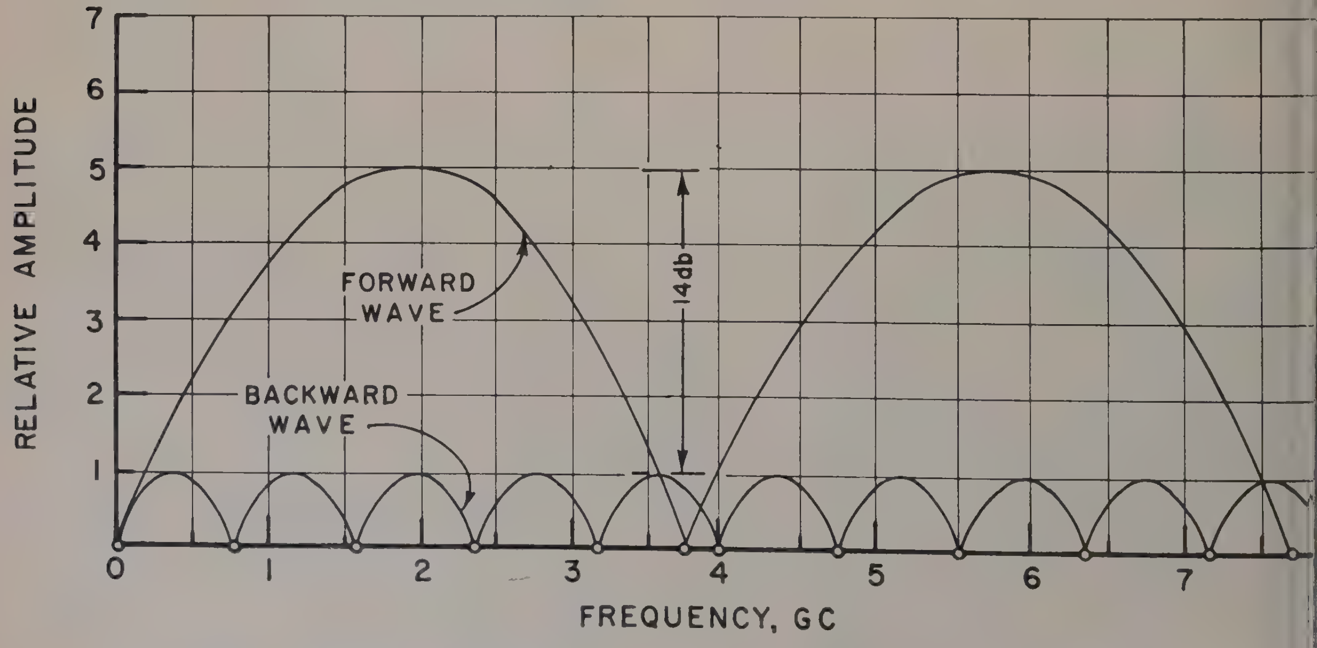

Figure 4 — Forward and Backward Wave, Matched Case, $\frac{\beta-\beta_0}{\beta_0}$ = 0.52, 15-cm Long Cable.

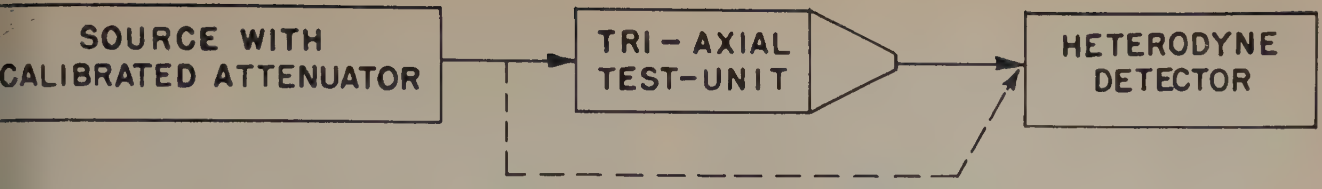

Figure 5 — Block Diagram of the Measuring System.

A null in this forward wave occurs when $(\beta-\beta_o)L=$ π and a maximum when $(\beta-\beta_o)L=(2n-1)\pi$. he variation of forward wave amplitude with frequency shown in Figure 4. Also shown is the backward wave, hich is the signal that would appear in a detector at the urce end of the outer line. This is obtained from Equaons (5) and (9) in the Appendix, employing a polyhylene-dielectric internal line and air-dielectric external ne.

easurement Procedure

In measuring the leakage power ratio, A^2, basically a bstitution technique is employed. A matched detector stem is installed at the output connector of the tri-ial unit, and the unit is driven as shown in Figure 5. In is setup, the short circuit is adjusted to produce a maxi-um indication at the detector. The detector is then con-cted directly to the source through a calibrated attenua-r, and the attenuation required to yield the initial de-ctor level is measured.

The sensitivity of this system is obviously limited by e sensitivity of the dectector and the power available. A nsitive superheterodyne system was employed, and for e low-leakage configurations about 30 milliwatts of ower was required.

The principal sources of error are attenuator errors and ismatch at the receiver (mixer) input. For connector easurements, the error due to mismatch is directly pro-ortional to VSWR since the equivalent leakage source pedance is small. The indicated leakage power can vary etween the extremes, P x VSWR to P ÷ VSWR, where is the power that would be delivered to a matched sys-m. A VSWR of 2 will produce ±3-db error therefore.

In advance of installing the inner coaxial system into e outer cylinder of the tri-axial system, the inner system ay be excited, and the immediate vicinity of the leakage oint or associated connector and attachment points probed ith a small loop or dipole to establish how critical are the ating of the connector and cable joints.

est Results

onnector Leakage and Surface Transfer Impedance

The above procedure was employed to assess the leak-e characteristics of three widely used connectors, the eneral Radio 874-B, the BNC (Bayonet Coupling), and e N (Threaded Coupling), and in addition, the new eneral Radio Locking Connector, the 874-BL which com-ises the basic 874-B Connector with an outer, threaded upling nut to shield and join the mating parts securely.

Leakage results are shown in Figure 6. These results ere transformed to equivalent transfer impedance, Z_{21}, d this result is shown in Figures 7 and 8.

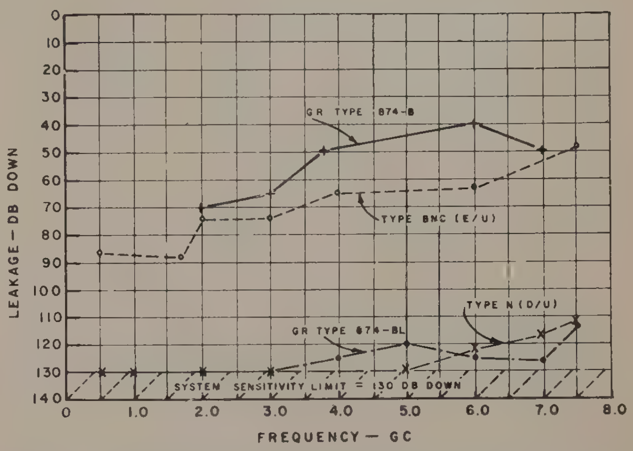

Figure 6 — Leakage Characteristics of the Type BNC, N, and General Radio Type 874-B, and Type 874-BL Connectors.

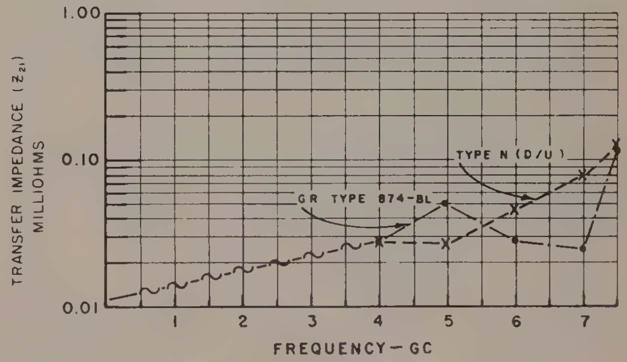

Figure 7 — Surface Transfer Impedance of the Type N and General Radio Type 874-BL Coaxial Connectors.

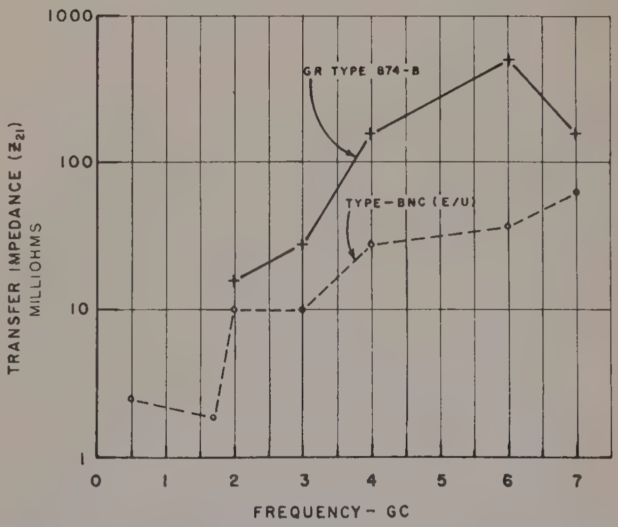

Figure 8 — Surface Transfer Impedance of the Type BNC and General Radio Type 874-B Coaxial Connectors.

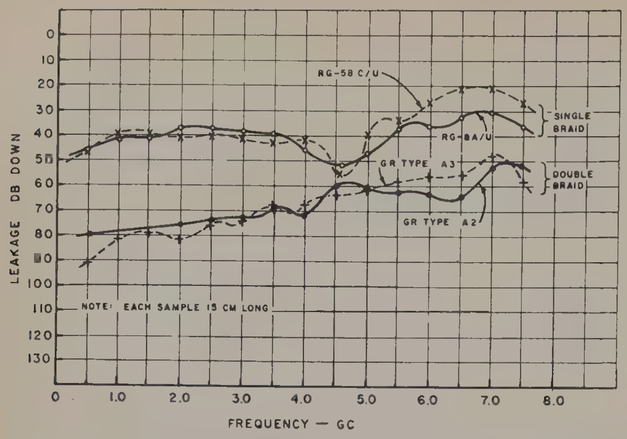

Figure 9 — Leakage Characteristics of RG-58, RG-8, and General Radio Types 874-A2 and 874-A3 Flexible Coaxial Cables.

The leakage characteristics of several popular flexible coaxial cables are shown in Figure 9. The RG-8 and RG-58 are single-braid cables. The General Radio A-2 and A-3 are double-braid cables of approximately the same size as RG-8 and RG-58 respectively. The corresponding surface impedance per unit length, calculated from the leakage measurements, is shown in Figures 10 and 11. Simple theory indicates that the transfer impedance is principally inductance. A linear surface impedance variation with frequency is, therefore, predicted. A linear frequency curve is shown in the graphs in this connection. For single-braid cables, the linear relation exists up to about 5 Gc, while for the double-braid cables the linear relation exists only up to about 2 Gc.

The single-braid leakage data indicate the periodicity expected in the forward wave launched by the leaky cable, and is explained, therefore, by an orderly arrangement of incremental leakage sources.

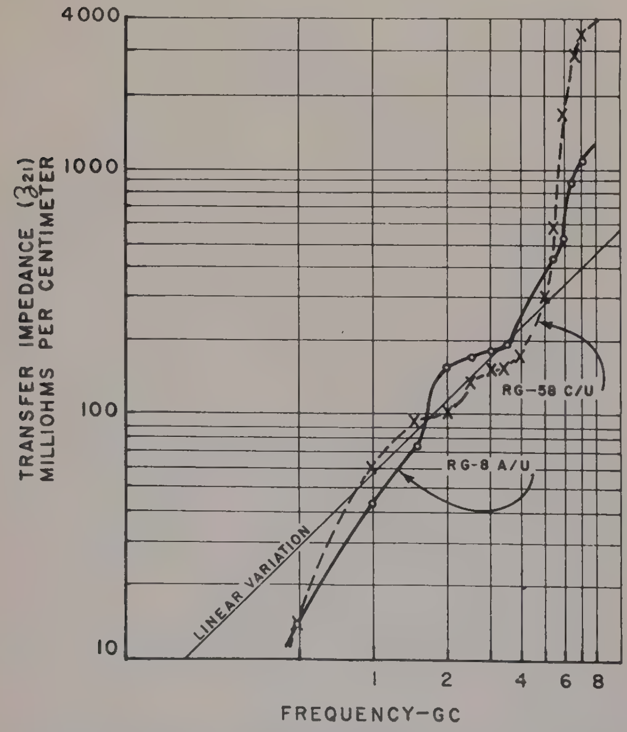

Figure 10 — Surface Transfer Impedance Per Unit Length of RG-58 and RG-8 Single-Braid Cables.

The double-braid data are devoid of the periodic var tion. Perhaps the double-shield arrangement cannot represented as a series of equal incremental generators well as can the single-braid, because the contact between t outer and inner braids may not be as regular as the wea of the braid. Subsequent measurements will be perform to verify this result, and to separate the forward and bac ward waves launched by the cable. This will permit more accurate measurement of transfer impedance.

APPENDIX

The Forward and Backward Waves Launched by Lea Cables—Analysis

Loose coupling between adjacent transmission lir under matched conditions has been analyzed typically Shelkunoff and Odarenko[13], and Jungfer[6]. An analysis given here for the coupling of the leaky cable into t secondary, external coaxial line of the tri-axial syste under general conditions of match. The particular case which the source end of the external, collecting line terminated in a short-circuit, and the output end of t external line is terminated in a load not matched to t line, is also analyzed.

Voltage at Output End and Forward Wave

The wave propagating toward the output is given as forward wave. It is the signal appearing at a detec

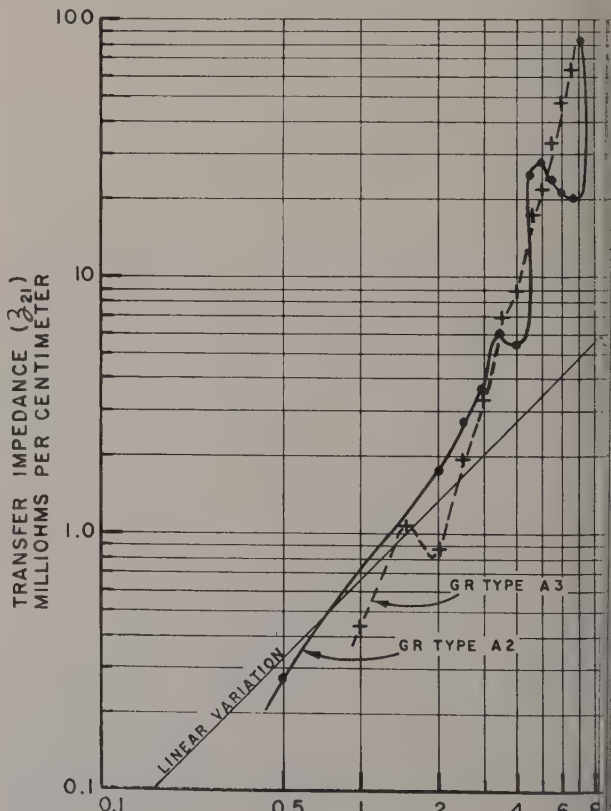

Figure 11 — Surface Transfer Impedance Per Unit Lengtl General Radio Types 874-A2 and 874-A3 Flexible Coa Double-Braid Cables.

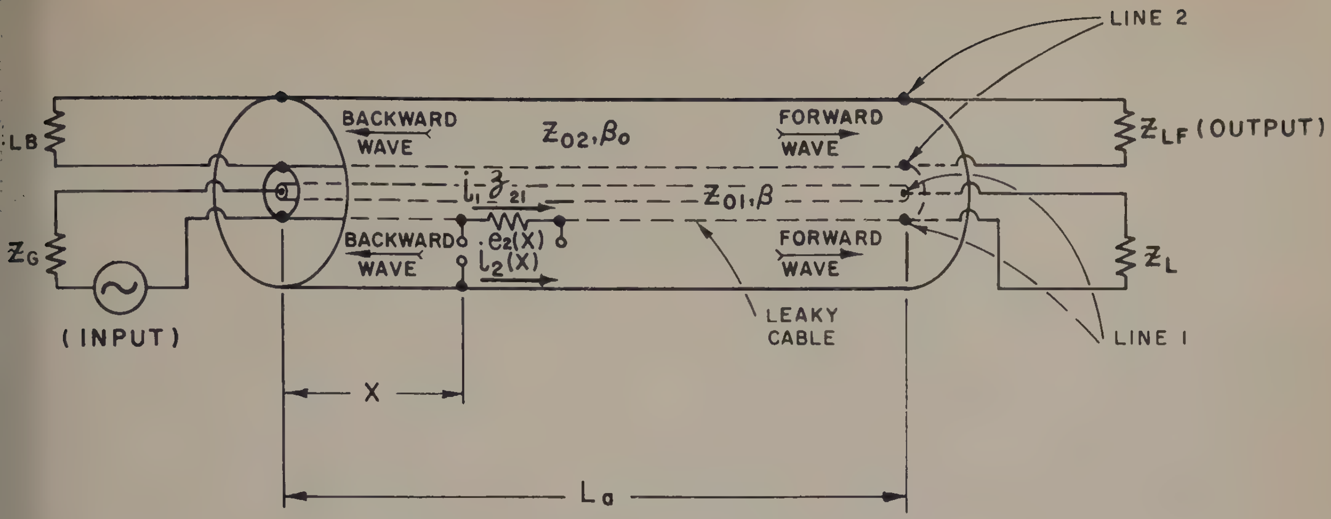

Figure 12 — Schematic, Tri-Axial Transmission System.

laced at the output end of the tri-axial unit under matched onditions. The total voltage at the output end is obined as follows:

In Figure 12, current, i_1, flowing internally in the able produces the voltage e_2 at the surface impedance, z_{21}. his voltage appears externally in series with the cable uter conductor and produces a current $i_2(x)$, in the uter line.

The wave to the right produced by $i_2(x)$ is obtained as ollows:

The incremental voltage e_2 at x is

$$e_2(x) = i_1 z_{21} e^{-j\beta x} \, dx \qquad (1)$$

where: i_1 = current in internal line (assumed uniform).
z_{21} = surface transfer impedance per unit length.
β = propagation constant in cable.

he incremental current in the external line 2, at plane x therefore,

$$i_e(x) = \frac{e_2(x)}{Z_2(x)}$$

$$= \frac{i_1 z_{21}}{Z_2(x)} e^{-j\beta x} \, dx \qquad (2)$$

here:

$Z_2(x)$ = the series combination of Z_{LF} transformed to plane x, and Z_{LB} transformed to plane x,
$= Z_B(x) + Z_F(x)$.

$$Z_B(x) = Z_{02} \frac{Z_{LB} + jZ_{02} \tan \beta_o x}{Z_{02} + j Z_{LB} \tan \beta_o x} .$$

$$Z_F(x) = Z_{02} \frac{Z_{LF} + j Z_{02} \tan [\beta_o(L_a - x)]}{Z_{02} + j Z_{LF} \tan [\beta_o(L_a - x)]} .$$

L_a = length of leaky cable.
β_o = propagation constant in external line.

The incremental voltage across the external line at = L_a, or across Z_{LF} is,

$$\begin{aligned} de_F = {} & [e_2(x) - i_2(x) Z_B(x)] \cos [\beta_o(L_a - x)] \\ & - j[i_2(x) Z_{02}] \sin [\beta_o(L_a - x)] \\ = {} & i_1 z_{21} \left[1 - \frac{Z_B(x)}{Z_2(x)} \right] \cos [\beta_o(L_a - x)] e^{-j\beta x} \, dx \\ & - j \, i_1 z_{21} \left[\frac{Z_{02}}{Z_2(x)} \right] \sin [\beta_o(L_a - x)] e^{-j\beta x} \, dx \qquad (3) \end{aligned}$$

Integration of (3), which is the summation of the contributions from the series of incremental leakage generators, yields the total voltage across Z_{LF}, that is,

$$\begin{aligned} e_F(L_a) = i_1 z_{21} \int_0^{L_a} \Bigg\{ & \left[1 - \frac{Z_B(x)}{Z_2(x)} \right] \cos [\beta_o(L_a - x)] e^{-j\beta x} \\ & - j \left[\frac{Z_{02}}{Z_2(x)} \right] \sin [\beta_o(L_a - x)] e^{-j\beta x} \Bigg\} dx \end{aligned} \qquad (4)$$

Note that when the external system is matched at both ends, (4) reduces to the forward wave:

$$e_F(L_a) = j \frac{i_1 z_{21}}{2(\beta - \beta_o)} e^{-j\beta_o L_a} \left[1 - e^{-j(\beta - \beta_o) L_a} \right] \qquad (5)$$

For the tri-axial connections described in the text, the output voltage was the sum of the complex voltages of the forward and backward waves obtained by integration of Equation (4).

For this setup, Z_{LB} was a short-circuited length of coaxial line of characteristic impedance Z_{o3}. In this case,

$$Z_{LB} = j \, Z_{03} \tan (\beta_o L_b)$$

In addition, the load Z_{LF} was not matched to Z_{02}, therefore, Equation (4) applies, employing the above substitution for Z_{LB} in $Z_B(x)$, wherein $Z_2(x) = Z_B(x) + Z_F(x)$.

In the experimental procedure, L_b, the length of the short circuit is adjusted to produce a maximum in the total voltage across Z_{LF}, the detector impedance. The result of integration of (4) for this general case is complex.

Therefore, in order to illustrate the summation of the forward and backward wave, when a short circuit is used, consider the case where the external line is terminated in a matched detector at the output end, and $Z_{O3}=Z_{O2}$. The total voltage across Z_{LF}, simplifies to,

$$e_F = \frac{i_1 z_{21}}{2}\left[\frac{1-e^{-j(\beta-\beta_o)L_a}}{\beta-\beta_o} + \frac{1-e^{-j(\beta+\beta_o)L_a}}{\beta+\beta_o}\, e^{-j\beta_o L_b}\right]$$

When the short circuit is adjusted for maximum output voltage this reduces to,

$$e_F(\max) = \frac{i_1 z_{21}}{2}\left[\left|\frac{1-e^{-j(\beta-\beta_o)L_a}}{\beta-\beta_o}\right| + \left|\frac{1-e^{-j(\beta+\beta_o)L_a}}{\beta+\beta_o}\right|\right]$$

The first term is recognized as the forward wave for the matched case, Equation (5). The second term is recognized as the backward wave for the matched case, Equation (9) below.

Voltage at Input End and Backward Wave

The wave propagating toward the source or input is given as the backward wave. It is the signal appearing at a detector placed at the input end of the tri-axial unit under matched conditions. The total voltage at the input end is obtained in the same manner as for the forward wave, yielding the following result:

$$e_B(o) = i_1 z_{21} \int_o^{L_a} \left\{\left[1-\frac{Z_F(x)}{Z_2(x)}\right]\cos(\beta_o x)\, e^{-j\beta x} - j\left[\frac{Z_{02}}{Z_2(x)}\right]\sin(\beta_o x)\, e^{-j\beta x}\right\} dx \quad (8)$$

This is the total voltage across Z_{LB}.

Note that when the external system is matched at b ends, (8) reduces to the backward wave:

$$e_B = j\,\frac{i_1 z_{21}}{2(\beta+\beta_o)}\left[1-e^{-j(\beta+\beta_o)L_a}\right] \quad (9)$$

These equations describe the frequency behavior of t tri-axial unit leakage output voltage, and relate this to t surface transfer impedance. The measured result is t ratio of power at output to power input incident on i ternal cable, and is directly related to e_F/i_1. The trans impedance, z_{21}, is calculated from this measured resu employing the value for L_a obtained by physical measu ment and from known or measured values of the propa tion constants β and β_o.

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SIGNAL PROCESSING ANTENNAS

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LAST OF TWO PARTS

Time Varying Antennas

1. *Time Varying Excitation Distributions*

This technique introduces a new parameter to obtain enhanced antenna performance. The parameter is in- duced by modulating the antenna excitation distribu- n as a function of time.[22] The variations may consist of nple on-off switching of elements or may involve com- ex temporal variations of amplitude and phase along e array. These temporal variations may be described in ms of the Fourier components present in the modula- n. Assuming 2M harmonic components, which are mul- les of the repetition frequency $f_0 = \frac{\omega_0}{2\pi}$, we obtain

$$\psi(s,t) = e^{j\omega t}\sum_{-M}^{M}\psi_m(s)\, e^{jm\omega_0 t} \qquad (21)$$

ere ω is the r-f or "carrier" frequency and s represents e source, or aperture variable. One may specify any mber of radiation patterns to be present simultaneously assigning the corresponding number to M and letting e various excitation distributions be modulated at the pective multiples of ω_0. The far field pattern is given by

$$g(\theta,\phi,t) = \sum_{-M}^{M} b_m(\theta,\phi)\, e^{j(\omega+m\omega_0)t} \qquad (22)$$

ere $b_m\ (\theta,\phi)$ is the far field pattern produced by the h harmonic component of the aperture excitation and given by

$$b_m(\theta,\phi) = \int \psi_m(s)\, G_m(\theta,\phi/s)\, ds \qquad (23)$$

ere $G_m(\theta,\phi/s)$ is the Green's function for the frequency $(\omega+m\omega_0)$ and for the surface upon which $\psi_m(s)$ is prescribed. The patterns given by the various $b_m(\theta,\phi)$ are independent of each other by virtue of the orthogonality of Fourier components, hence, the various patterns do not interact with each other and by appropriate filtering may be separated.

A rather simple example of a commonly used modulated antenna is the conically lobing antenna. The pattern produced by this antenna consists of a fixed crossover level around which the peak of the beam is rotating and providing the lobing signal. From the Fourier analysis point of view the output pattern should consist of a d-c pencil beam and a monopulse difference pattern at the lobing frequency. This was experimentally verified, and the output shown to contain these two patterns at dc and the lobing frequency, respectively.

Just as the lobing antenna provided two components of the Fourier sum (Equation 22), one can obtain a large number of different patterns for multiple track while scan, or for simultaneous scanning operations. In principle there is no limit on the number of simultaneous patterns achievable, but in practice the two main problems are: first, to

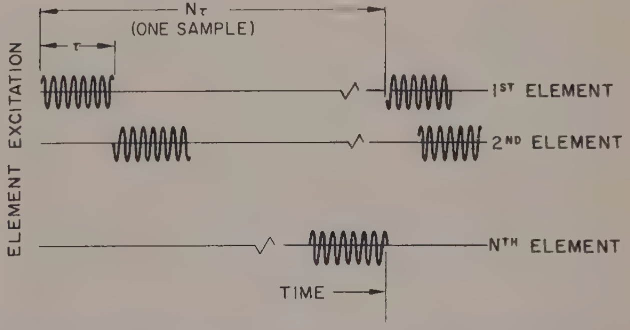


Figure 12 — Excitation of a simultaneously scanning N element array.

produce the complex temporal excitation across the aperture to obtain the desired patterns, and second, to design the proper filters to separate the frequency components which are very closely spaced (since $\omega >> \omega_0$). Certain pattern combinations lead to reasonably simple excitation distributions and have been successfully implemented. A rather important and useful example is that of simultaneous scanning. It has been shown[23] that one can produce a set of simultaneous beams pointing in various directions in space by sending an r-f pulse along an array. Thus, each frequency harmonic is related to a given direction in space, and the angular information regarding the location of a target is obtained from the frequency of the signal received from the array. The practical implementation involves a sequential on-off switching of the elements of an array as shown in Figure 12.

The expression for the excitation may be given by

$$f(x,t) = e^{j\omega t} \sum_{m=0}^{N-1} \delta(x-md)\ [U(t-m\tau) - U(t-[m+1]\tau)] \qquad (24)$$

where d is the distance between consecutive elements, τ is the pulse length and N is the total number of elements. U is the unit step. The whole sequence repeats every $N\tau$ seconds, that is, after the last element is switched off, the first element is switched on again, etc. The resultant far field pattern is given by

$$g(\theta,t) = \sum_{n=-\infty}^{\infty} \frac{\sin\frac{n\pi}{N}}{\frac{n\pi}{N}} \frac{\sin\frac{N}{2}\left(k_n d \sin\theta - \frac{2\pi n}{N}\right)}{\sin\frac{1}{2}\left(k_n d \sin\theta - \frac{2\pi n}{N}\right)} e^{j\frac{N-1}{2}\left(k_n d \sin\theta - \frac{2\pi}{N}\right)} e^{-j\frac{n\pi}{N}} e^{j(\omega+n\omega_o)} \qquad ($$

where $k_n = \frac{\omega + n\omega_0}{c}$ and ω_0 is the lowest frequency harmonic of the modulating signal and is related to the pulse repetition period $(N\tau)$ by $\omega = \frac{2\pi}{N\tau}$, and c is the velocity of light. The resultant pattern is shown in Figure 13.

The above scheme may operate on receive, transmit or the "two-way" mode. In the receive mode one samples the incoming signal which may be cw or pulsed. In the case of the pulsed radar it is important that the switching or sampling rate be fast enough such that the incoming pulse be at least ten times longer than $N\tau$. This is to ensure that the energy is concentrated around the spectral lines corresponding to the various directions in space as shown in Figure 13. To obtain separate lines as the picture indicates one has to have an infinite number of repetitions to form a true Fourier series. If only a single sample were received a continuous spread of energy would result over all frequencies corresponding to the transform of a single pulse. As more samples are taken the energy concentrates about the proper frequencies permitting a reasonable separation between the various directions in space. Figure 13 depicts the beams formed in the idealized case of $\tau \rightarrow 0$, that assumes an infinite switching rate or a pulse of zero duration traveling at infinite velocity along a continuous array. For a finite pulse τ of given shape the envelope of the frequencies will not be constant (as shown

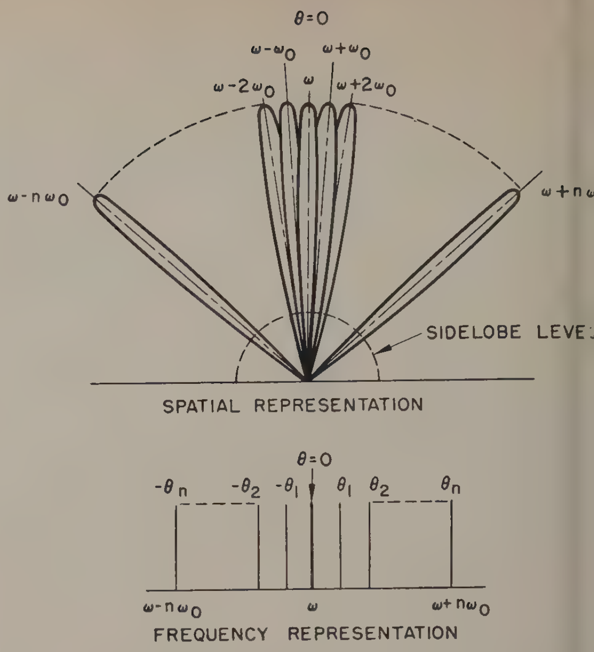
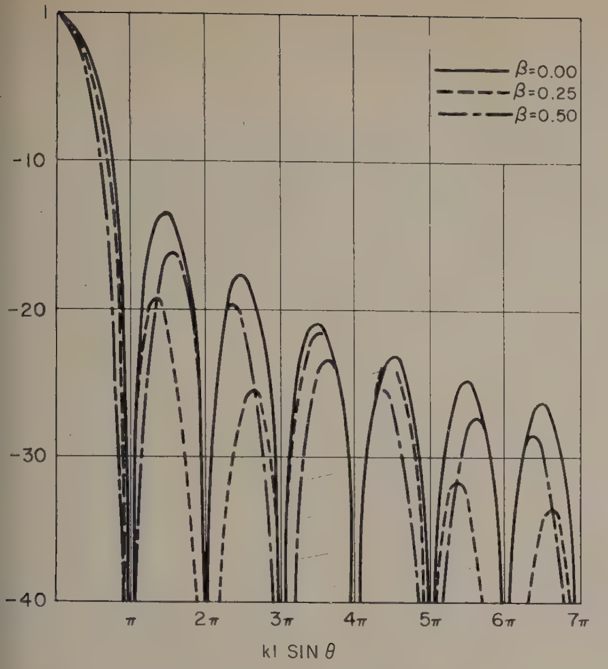


Figure 13 — The patterns produced by a simultaneously scanr array.

in Figure 13) but will have the form of the Fourier tr form of the pulse shape. Another factor in determin the relative intensities of returns from different angle of course, the directivity of the array elements. These tors may be used to limit the angular observation rang a specified sector.

The simultaneous scanning technique has numerous vantages and some shortcomings. The most importan vantage is in its simultaneous nature, while its most portant disadvantage is in its total reliance on frequ characteristics. Thus, the angular location of the targ given by the spectral characteristic of the signal and frequency changes such as doppler shifts may cause se problems. The gain characteristics as well as mul target resolutions may be made comparable to those o conventional antenna, but the processing, involving accurate frequency filtering and multichannel operatio quite complex and expensive.

Another application of the time domain techniq sidelobe suppression. If one could move, as a functio time, the angular position of the sidelobes of a pa without affecting the main beam, then averaging the put before detection would result in substantial sid suppression. The averaging has to be carried out b detection to take advantage of the phase interference tween the sidelobes. A rather simple method of obtai the desired sidelobe "motion" is by modulating the le of the array without changing its aperture distribu Thus, if a uniformly illuminated array of length l_o is m lated in length by an amount βl_o as a function of time



igure 14 — Time average patterns of a square-wave switched array with uniform illumination. β represents the fraction of the array that is switched on and off.

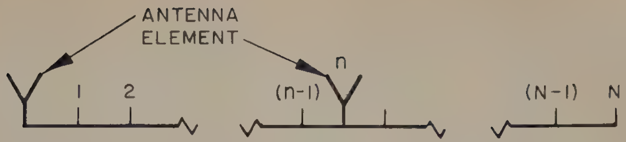


Figure 15 — Ryle and Hewish synthetic antenna.

he far field pattern would be proportional to

$$g(\theta,t) = A\,\frac{\sin\{kl_o[1+\beta\,f(t)]\sin\theta\}}{\sin\theta} \qquad (26)$$

vhere A contains the parameters and variables not affected y the modulation. Now, if a coherent averaging operaion is carried out such as filtering out all except the carier, or the d-c term of the modulation function, the reultant is

$$b_o(\theta) = A\,\frac{\sin\,(kl_o\sin\theta)}{\sin\theta}\cos\,(kl_o\,\beta\sin\theta) \quad (27)$$

vhere $f(t)$ was assumed to be a square wave, namely, the ength βl_o is alternately added and removed from the rray. Note the additional directive factor cos $(kl_o\,\beta\sin\theta)$ vhich reduces the sidelobes without affecting the peak of he main beam. Figure 14 shows the effect of various alues for β. The optimum value of β, which is 0.25, reluces the sidelobes of the original uniformly illuminated rray to 23 db, or approximately by 10 db.

The most important advantage of this technique is not n aperture savings but in easing of tolerance requirenents. Thus, for low sidelobe arrays which require very lose tolerances for the aperture excitation, these requirenents may be carried over to the time element where exremely close tolerances are relatively easy to obtain.

The time domain sidelobe suppression was successfully mplemented at Hughes Aircraft Company with results losely agreeing with theoretical prediction.[24] The simulaneous scanning has also been experimentally verified and he actual equipment was portrayed on the cover of the)ctober issue of *the microwave journal*. The most important experimental difficulty in the time domain application is in obtaining fast, accurate and repeatable radiation control devices which would preferably be an integral part of the antenna itself. Experiments on devices such as diodes mounted close to or inside a slot and varying the amplitude and phase of the radiating (or receiving) slot at kilo or megacycle rate are now in process. The simplest kind of variation presently achievable is an off-on switch action which happens to be adequate for the present application of both sidelobe suppression and simultaneous scanning.

2. *Time Variable Arrays*

This section is concerned with aperture changes in time which are much more drastic than those discussed in the former section, and the objectives are entirely different. In fact, the time element comes in only in the sense that successive measurements are made at different times. The main objective of this technique[25] is to synthesize a very large antenna by means of a pair of small mobile antenna elements which are made to cover in successive steps the area occupied by the equivalent large antenna. As shown in Figure 15 the first element may be kept stationary while the second element successively occupies all the N positions along the antenna which would be occupied by permanent elements in the conventional equivalent. This synthesis is a valid equivalent of the linear array as can be seen from the following considerations. In an ordinary linear array the output is obtained by summing the signals induced on each element of the array. If the source is constant one may measure the induced signal at each of the points successively rather than simultaneously and add the output with identical results. The only difficulty may be encountered in connection with the phase since the contributions must be added with the correct relative phase. In the case of a coherent, say monochromatic, source the appropriate phase can be obtained from the time delay between measurements. For the case of an incoherent source one can measure the relative phase by using, simultaneously, two elements rather than one, and that is the reason for the presence of a pair of elements in the setup by Ryle and Hewish who applied the technique to radio astronomy. The above discussion referred to a one-dimensional array but the same applies, of course, to two-dimensional arrays with a much greater saving in elements. The above results obtained from a qualitative discussion can be easily verified quantitatively. Consider a plane wave incident on an array of N elements, the power recevied from the array is given by

$$P = \sum_1^N I_n e^{j\phi_n} \sum_1^N I_n e^{-j\phi_n} = \sum_1^N I_n^2 + \sum_1^N \sum_1^N I_m I_n \cos\,(\phi_m - \phi_n) \qquad (28)$$

where $I_n e^{j\phi_n}$ is the excitation of the nth element. The first term is just the summation of the signal intensities at each element which may be measured independently of each other. The second term may be obtained from the interferometer measurements either by connecting Ryle's[26] phase switching receiver to the two elements as they pass the various positions (m, n) or by forming a product of the outputs and averaging. Carrying out the latter operation, we obtain

$$\frac{1}{2T}\int_{-T}^{T} I_m \cos(\omega t+\phi_m)\, I_n \cos(\omega t+\phi_n)\, dt \simeq$$

$$\frac{1}{2} I_m I_n \cos(\phi_m-\phi_n) \qquad (29)$$

where ω is the operating frequency of the receiver. The scanning of the array is performed by adjusting the value of $(\phi_m-\phi_n)$ to give a progressive phase shift across the array. For this purpose $I_m I_n \sin(\phi_m-\phi_n)$ is needed, but this can be obtained by connecting the pair of elements in phase quadrature to the phase switching receiver or the correlator. Also any arbitrary excitation or weighting amplitude may be assigned to each point of the aperture since the individual measurements may easily change the attenuation (or amplification) settings. The main disadvantages of the system are computational complexity, loss in S/N and the inherent restriction that the source be constant during the time that the measurements are carried out. Most of these limitations are not objectionable in radio astronomy where signal-to-noise ratio is not critical in view of the large integration times, and in many cases, such as solar measurements, the problem is excessive signal in which case this technique is very beneficial. The source constancy is again a small problem in radio astronomy but may be quite severe in the radar case unless the antenna element moves very fast as compared to the source. Observation time may not be at a disadvantage due to the fact that the synthetic scheme saves time in comparison to the conventional array, since the actual scanning is performed by introducing the required phase delays in the computing stage.

In summary, the technique has substantial merits for radio astronomy as evidenced by the successful implementation of the system[25] and has reasonably good potential for radar applications.

VI. Wide Signal Band Antenna Systems

1. *Correlation Processing*

As in the time domain technique a new parameter is introduced to improve the antenna characteristics, namely, wide band signals. Thus, one may expect an enhancemen without necessarily paying a corresponding amount i other performance aspects. Of course, the obvious penal is the equipment sophistication and complexity require for proper wide band operation and, of course, the nee for wide band antennas.* The principal use of bandwidt in the application to be discussed now is in increasi directionality. Consider two identical elements, separate by a distance d, whose outputs s(t) are cross correlate that is, multiplied and averaged (see Figure 16).

The output of the correlator is given by the autocorre tion function

$$R(\tau)=\frac{1}{2T}\int_{-T}^{T} s(t)\ \ s(t+\tau)\, dt \quad (T\rightarrow\infty) \quad (30$$

where $\tau=\frac{d}{c}\sin\theta$, is the difference in the time of a rival of the wave front at the two elements (c is th velocity of light). Assuming a square frequency spectru of width 2W centered at W_o, and using the Wiener Khin chine relations[27] between the spectrum and the correlatio function we obtain

$$R(\tau)=\int_{W_o-W}^{W_o+W} \cos(\omega\tau)\, d\omega=\cos\left(W_o\frac{d}{c}\sin\theta\right)\frac{\sin\left(W\frac{d}{c}\sin\theta\right)}{\frac{d}{c}\sin\theta} \qquad (31$$

Thus, the output will be a function of the angle of arriv and will exhibit a directionality shown in Figure 17. No that the width of the main beam of the $\frac{\sin x}{x}$ factor directly related to the bandwidth of the signal. Thus o can produce a directional effect in a two-element array

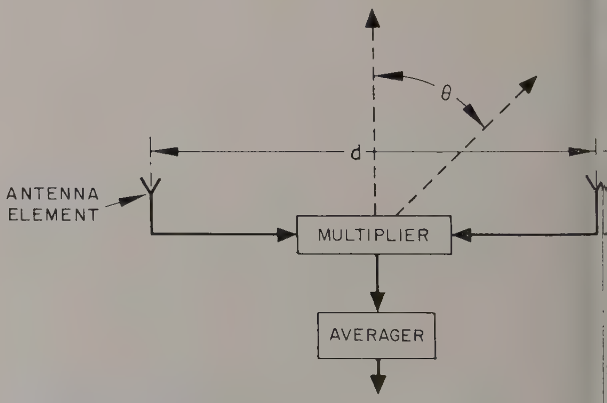


Figure 16 — Wide band correlation array.

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* *It should be mentioned that the time varying antennas do necessarily require wide band capabilities since the modulat frequency band may usually be made a small percent of the frequency. As to the "traveling pulse" for simultaneous sc ning purposes very fast switching may require wider ba widths.*

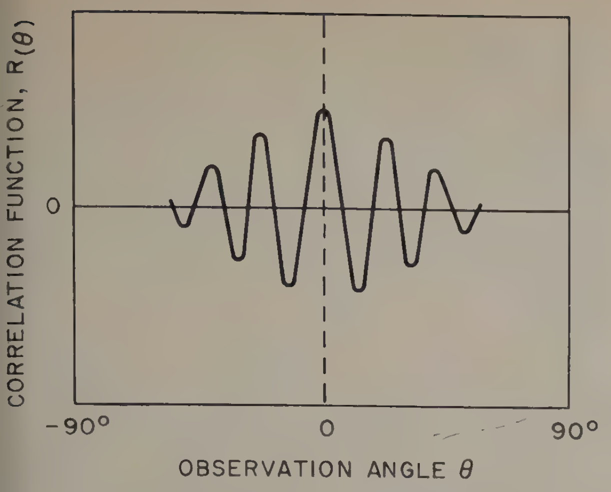

Figure 17 — Pattern obtained by correlating the output of two antenna elements receiving wide band signals.

using wide band signals with the directionality being directly proportional to the bandwidth.[28]

Instead of using a signal which contains a continuum of frequencies over the specified bandwidth W, one may use a set of discrete frequencies which cover the same bandwidth with similar effects on directionality.[29] The difference will be the same as that between a continuous and a discrete linear array,[30] that is, as long as the separation between the discrete frequencies is small enough the appearance of spurious beams will be avoided. Note that one may replace the multiplier (Figure 16) by a square law detector and still obtain directionality with a wide band signal. The result of such a processing is given by

$$\frac{1}{2T}\int_{-T}^{T}\left[S\left(t+\frac{d}{2c}\sin\theta\right)+S\left(t-\frac{d}{2c}\sin\theta\right)\right]^{2} dt = 2\,R(o)+2R\left(\frac{d}{c}\sin\theta\right) \qquad (32)$$

In this case, there is a constant term in the output which is not a function of θ and which does not permit the same amount of total signal variation as in Equation (31).

2. *Matched Filter Technique*

We have shown in the above discussion (Equation 31) that one can obtain improved directionality by using wide band signals. The present technique achieves a similar result by passing the signals of an additive array through a matched filter.[31,32] Consider a two-element array at $\pm x_1$ as seen in Figure 18. The output of the matched filter is the summation of the autocorrelation functions of the signals from the elements of the array.* Thus, when the wave arrives at x_1 it will emerge as an autocorrelation function (of time). If the wave has a square frequency spectrum, the output will have the form of $\frac{\sin x}{x}$ with its "beam width" determined by the bandwidth of the signal.** At a time $\frac{2x_1 \sin\theta}{c}$ later the same pulse will arrive at the other element with a similar result. At any time (t) the output function will be given by

$$\phi(u,t)=R\left(t-\frac{x_1u}{c}\right)+R\left(t+\frac{x_1u}{c}\right) \qquad (33)$$

where $u=\sin\theta$. If the time (t) is referred to the center of the array, that is, if we measure the response at the time the wave passes the center of the array we obtain

$$\phi(u,o)=\phi(u)=R\left(-\frac{x_1u}{c}\right)+R\left(\frac{x_1u}{c}\right)=2R\left(\frac{x_1u}{c}\right) \qquad (34)$$

which has a form similar to the output of the correlator given by Equation (27) and shown in Figure 17. [$R(\tau)$ is assumed to be an even function of τ.]

To obtain the same directionality from an array excited by a narrow band signal would require the aperture excitation shown in Figure 19, where k is given by $2\frac{W}{W_0}$, or the percent bandwidth of the wide band signal. Thus the advantage is two-fold, the effective element density is increased from point sources to line sources of width kx_1, and also the overall equivalent aperture length is increased by the same percent as the percent bandwidth of the wide band signal.

The scanning of the array may be performed electrically by inserting variable time delays between the element outputs and the matched filter. A true time delay rather than

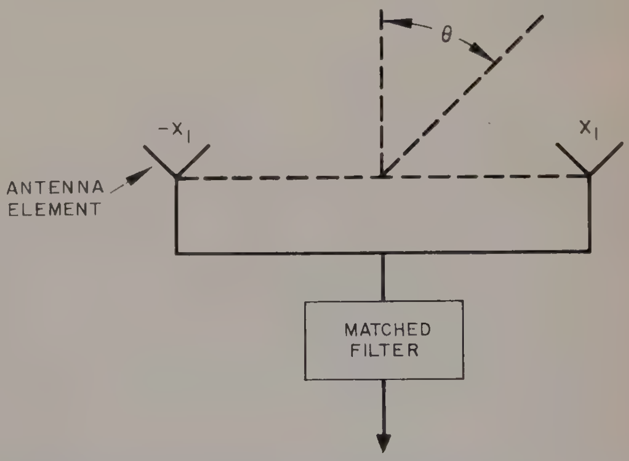

Figure 18 — A two element interferometer using a matched filter processor.

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* *A matched filter has a spectrum which is the complex conjugate of the spectrum of the signal to which it is matched. The spectrum of the output is thus the absolute value squared of the input spectrum. The inverse transform is proportional to the autocorrelation of the input time function.*

** *The actual output will not be exactly of that form and should be computed once the actual impulse response of the filter and the input time functions are known. The real output will differ somewhat from the sin x/x shape (which is not realizable) but this modification does not modify significantly the directional properties of the array.*

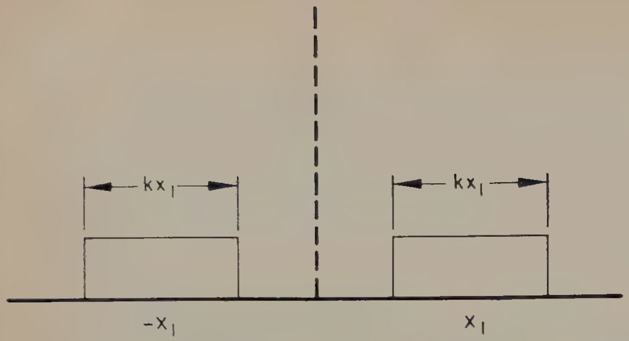

Figure 19 — Excitation distribution of a single frequency array which is equivalent to a two element matched filter array.

a phase shifter is necessary because of the wide frequency band present in the incident wave.

The two-element array may be extended to a multi-element array (2N elements) in which case the pattern is given by

$$\phi(u) = \sum_{-N}^{N} I_n \, R\left(\frac{n\triangle u}{c}\right) \qquad (35)$$

where the excitation of the nth element is given by I_n and the distance between successive elements is given by $\triangle$. The argument of $R(\tau)$ in Equation (35) represents the increasing time delays (τ) between the successive pairs of elements; for example in the nth pair of elements, which are $2n \triangle$ units of length apart, the delay time is $\frac{2n\triangle u}{c}$. If one lets the spacing $\triangle$ become increasingly smaller a continuous aperture is obtained whose output is given by

$$\phi(u) = 2 \int_0^\infty I(x) \, R\left(\frac{xu}{c}\right) dx \qquad (36)$$

Since $\phi(u)$ may be considered to represent the far field pattern of the aperture it is interesting to obtain the equivalent frequency aperture needed to obtain the same pattern. This is given by

$$I_o(y) = \frac{\omega_o}{\pi c} \int_0^\infty \phi(u) \cos\left(\frac{\omega_o u y}{c}\right) du \qquad (37)$$

which after some algebra results in

$$I_o(y) = 2\,\omega_o \int_0^\infty \frac{I(x)}{x} \, G\left(\frac{\omega_o y}{x}\right) dx \qquad (38)$$

where G (f) is the frequency spectrum of the signal, y is the aperture variable of the equivalent aperture, and ω_0 is the r-f frequency. From Equation (38) it is clear that the original aperture is extended by the finite bandwidth of G. This effect can be seen by considering I (x), which represents the aperture distribution of the wideband antenna, to be a set of discrete elements, namely delta functions $\delta(x_n)$. Carrying out the integration we obtain

$$I_o(y) = 2\,\omega_o \sum_n \frac{I(x_n)}{x_n} \, G\left(\frac{\omega_o y}{x_n}\right) \qquad (39)$$

Since G(f) was assumed to have a bandwidth 2 W, it means that $I_o(y)$ will extend over all the intervals for which $(\omega_o - W) < \frac{\omega_o y}{x_n} < (\omega_o + W)$. Thus, the equivalent aperture will consist of a set of line sources rather than point sources just as in the two-element array of Figure (19) (the size of the equivalent line sources varies with x_n). It follows from the above discussion that both aperture size and density of elements can be saved. For example, one can simulate a 200-element uniformly illuminated array by means of a 66-element array with the elements spaced at prescribed distances which can be obtained from Equation (39). In addition, this method has the advantages that nonlinearities are not involved and that the signal-to-noise ratio is maximized by the matched filter.

The question is, what is the price. First, of course, is the bandwidth. Introducing the additional parameter does improve the system's performance; one, however, pays in system complexity and sophistication. The multiple target ambiguity is present here too, i.e., if several waves arrive simultaneously it may be difficult to determine their respective angles of arrival. Another problem is the range information required to determine the t=0 reference point which is required in order to obtain the antenna response. Thus, the return signal is first recorded and the appropriate point on the record has to be determined for each scan angle. This is a rather complicated method of finding the response of the antenna, and moreover the point t=0 will usually be at a low signal to noise level, unless there is a single target at broadside. One may increase the efficiency of the system by utilizing the total response rather than selecting a single point. For example, the return from a target will usually be a series of $\frac{\sin x}{x}$ pulses corresponding to the passage of the return wave through the successive elements of the array. One may obtain the angle of arrival by measuring the pulse separation, without resorting to scanning. If however, the signal-to-noise ratio is too low to detect the individual pulses one may steer the array by introducing progressive time delay between the elements and thus causing the pulses to superimpose. The multiple target resolution of the system will be significantly improved for arrays consisting of a large number of elements. This is due to the fact that when the array is scanned towards a target the response will be very large compared to that of a single element response. Thus the $\frac{\sin x}{x}$ pulses resulting from the responses of individual elements to various targets will be negligibly small even if several of them combine by coincidence as compared to the joint response of the whole array to each target.

The matched filter technique may be soon implemented due to successful microwave pulse compression techniques developed at Hughes Aircraft Company and Lincoln Laboratories. Another important component that is essential to the scanning of the array is a variable nondispersive delay line. This, also, is in an advanced development stage and expected to be available in the near future. Thus, it may be expected that experimental tests on the system will shortly be carried out to verify the theoretical results.

VII. Noise Considerations

There are two main sources of noise. One is receiver noise added to the signal emerging from the antenna. The noise contributed by the antenna and the connecting network may be combined with the receiver noise and referred to the receiver output or input terminals. The signal-to-(receiver) noise ratio is directly related to the gain of the antenna and this is where most data processing antennas are significantly inferior to the linear antenna. The main reason for the loss of gain in nonlinear antennas as well as in the switching antennas is the method by which the improvement of resolution or beam shape is obtained. The nonlinear, or switching antenna, rejects or suppresses the power in the undesired portion of the radiation pattern instead of converting it into additional useful power at the desired angles. A second source of signal-to-noise degradation in the nonlinear antenna is the nonlinearity itself which increases the noise by adding to it signal-noise cross-terms. Of course the nonlinear element itself will also contribute some noise. We can see that the nonlinear processing group which improves quite remarkably the directionality of an antenna, and very often increases the resolving power as well, suffers significant degradation of S/N ratio. These types of processing antennas are therefore best suited for applications where the S/N ratio is quite high and can be traded for improved resolution or directionality.

Regarding the time domain techniques, the scheme which might lose in S/N ratio is the simultaneous scanning, since in this scheme only one element is on at one time, which reduces the potential gain of the array by the number of elements. More efficient ways of utilizing the array are, however, available although they require more complex circuitry. The stacked beam array is of course linear, hence no degradation may be expected except for plumbing losses. As to the matched filter antenna discussed in Section VI, the peak signal-to-noise ratio is maximized and nonlinearities are absent; hence, no degradation should be expected in this scheme.

A substantially more complicated problem is that of external noise which includes natural or man-made noise reaching the antenna together with the desired signal and contaminating it. This definition of noise may be extended to include any undesired signal whether a point source as a jammer or an extended source such as atmospheric or galactic noise which is considered to be spread uniformly over the sky. The interference rejection properties of the array are the characteristics of importance in this case. That is, the presence of cross terms due to the nonlinearities produced by the processing will degrade the performance of the antenna even if the interference is uncorrelated with the desired signal. It was mentioned above that the cross terms would vanish for incoherent sources; however, this assumed infinite time averaging which is of course impossible. The longer the integration is carried out the better the signal-to-noise ratio becomes under most conditions. The same situation holds here too, the performance of the linear array may be closely approximated if sufficient integration time is permitted; thus, one trades array length for time, if the signal-to-noise ratio is to be preserved.

This assumes, however, that the nonlinearities are not of the multiple sequential type. In the latter case the performance of the linear array may never be duplicated, since, as pointed out in Section IV, some of the terms are correlated even for incoherent sources. A detailed comparison[33] between a single correlation antenna and one containing multiple consecutive nonlinearities has shown that for equal integration time and similar inputs the output signal-to-noise ratio was several times higher in the single correlation type than in the multiple one. An interesting comparison was carried out between a linear antenna and an Arsac array of the same overall length but half the number of elements.[34] The processing in this type of array consists of cross correlating all elements of the array and summing the outputs. The single target noise-free response of the antenna is identical to that of the linear array. Thus, this type of processing antenna reduces the element density as compared to that of a linear array but does not increase the effective length. The multiple target response of the antenna is far better than that of the Berman and Clay type of arrays and is only slightly worse than that of its linear equivalent. Nevertheless, when noise sources are present, the cross terms contribute to an a-c power output representing the noise fluctuation, eight times as high as that of a linear array. A detailed computation for the Arsac array followed by a square law detector showed that only when the total noise power in the background is equal to or smaller than the power arriving from the desired source do the a-c terms of the linear and nonlinear array compare in magnitude. Thus, in the presence of external noise, the various processing antennas, and particularly the ones involving multiple nonlinearities, are apt to suffer more than their linear equivalents. The amount of degradation varies, but a careful evaluation is necssary to determine the type and extent of error that the various disturbances may cause.

VIII. Conclusions

The above discussion was a brief exposition and evaluation of the most prominent of a large group of data processing techniques. The new techniques offer significant advantages over the conventional antennas but at the same time impose penalties on certain performance characteristics. Thus, a trade is involved. The possibility of a tradeoff in itself may be very useful and important but the difficulty often is to determine accurately the nature of the tradeoff. The present paper attempted to point out the areas of tradeoff involved and the reasons behind them. However, for a specific application a detailed evaluation must be carried out to determine quantitatively the tradeoff and thus choose the optimum system. The referencing in the paper is expressly for that purpose, that is, to provide the necessary guide to the available literature on the various topics discussed and thus supply the tools for a detailed analysis.

Acknowledgment

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32. Turin, G. L., "An Introduction to Matched Filters," *IRE Trans.* vol. IT-6, No. 3, June 1960, p. 311.

33. Fakely, D. C., "Comparison Between the Performances of Time-Averaged Product Array and an Intraclass Correlator," *J. Acoust. Soc. Am.* vol. 31, 1959, p. 1352.

34. White, W. D., C. O. Ball, and M. Deckett, "Final Report on Non-Linear Antenna Study," Contract Af 30 (602)-1873 RADC-TR-59-179, Sept. 1959.

Corrections

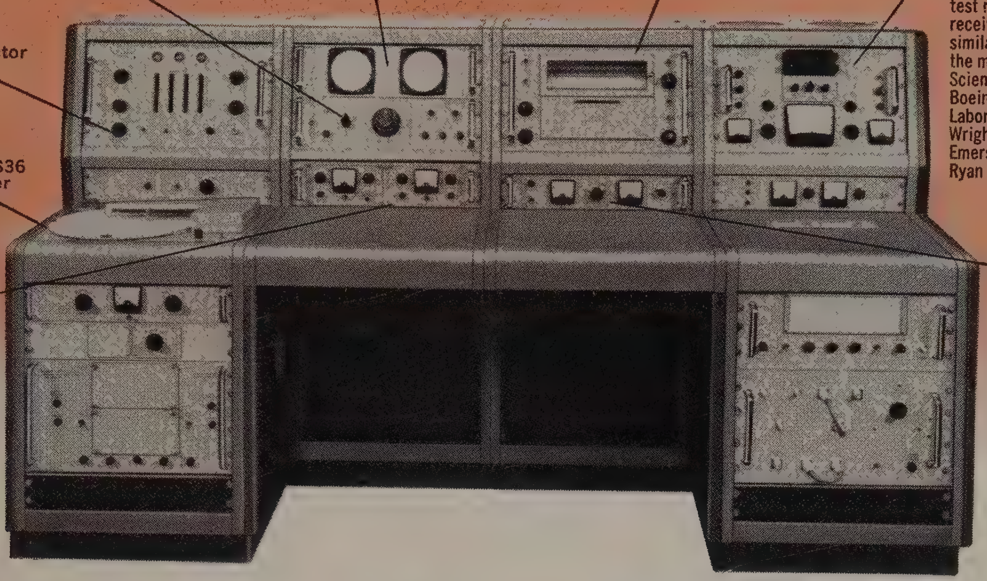
In the paper, "Microwave Two-Phase Converters for Imageless Receivers," by Robert B. Wilds, appearing in the September, 1961 issue, there is an error in Figure 3. The characteristic impedance of the input arm of the power divider should be 43 ohms instead of 35.4 ohms, and characteristic impedance of the output arms should be 61 ohms instead of 70.7 ohms. The description of the power divider design in Paragraph III of the text is also in error in this respect.

In the paper, "An Accurate Attenuation Measuring System With Great Dynamic Range," by B. O. Weinschel, appearing in the September, 1961 issue, the equation used in the upper right-hand corner of Figure 4, on page 79, should read

$$\%\ \text{increase} = \left[\frac{1}{2\sqrt{\pi\eta}}\, e^{\frac{-\eta^2}{2}} \left[(1+\eta^2)\, I_0\left(\frac{\eta^2}{2}\right) + \eta^2 I_1\left(\frac{\eta^2}{2}\right)\right] - 1\right] 100\%$$

On page 78, in the middle of the first column, it reads:
"S_1=Error in Source or Load Impedance."

This should read:
"S_1=Residual VSWR of Load and Generator."



Heart of most modern antenna test ranges is a Scientific-Atlanta receiving and recording console, similar to the one shown. Among the many ranges instrumented by Scientific-Atlanta are those at Boeing-Wichita, at MIT's Lincoln Laboratory, Douglas El Segundo, Wright-Patterson Air Force Base, Emerson and Cuming, and Ryan Aeronautical Company.

ONE SOURCE
For Complete Antenna Instrumentation Systems

Recording, Receiving, Transmitting and Control Equipment, Antenna Positioners, Microwave Components, and Recorder Supplies

PATTERN RECORDERS—Two basic pattern recorders are available: the Series APR 20 Rectangular, and Series APR 30 Polar. They can be combined to form the popular APR 20/30 Polar-Rectangular Recorder. Pen responses include logarithmic, linear, and square root.

Features include servo control with tachometer feedback, a noise compression circuit, an electric pen lift, and a three-axis synchro input selector. The rectangular recorder has an automatic chart-cycle advance, illuminated chart, three chart scale expansions with forward-reverse, and chart position control. The polar recorder features a recording diameter of 7 and 13 inches, a turntable slip-clutch, pen standby and load switch, calibrated turntable, and chart center light.

WIDE RANGE RECEIVING SYSTEM—A double conversion superheterodyne receiver, the Scientific-Atlanta Series 402 covers the range from below 30 mc to more than 100 kmc.

Features include a sensitive AFC circuit which prevents the receiver from losing track during transmitter frequency drift. One coaxial cable eliminates costly lossy wave guides and rotary joints. Antennas can be located up to 75 feet away with negligible loss in sensitivity, or more than 200 feet away with low loss cables. Reception of cw signals from simple sources eliminates need for precise modulation.

Excellent employment opportunities exist for electronic, microwave, and mechanical engineers.

Modification P-4 adds 20 db to the normal 40 db dynamic range providing 1 db linearity over a full 60 db dynamic range. Modification Z adds a precision IF attenuator and VTVM appreciably reducing the number of components and instruments required for level, gain, and isolation measurements.

ANTENNA POSITIONERS—Scientific-Atlanta offers medium and heavy duty azimuth and multi-axis antenna positioners. Standard models range from the PMA-3 medium duty azimuth positioner designed for a maximum vertical load of 200 pounds with a maximum bending moment of 200 foot pounds to the large PAEA 29 H azimuth over elevation over azimuth for vertical loads of 15 tons and a bending moment of 30,000 foot pounds.

Features include use of Kaydon four-point contact bearings which minimize sliding friction, weather and dust proof design, and 1:1 and 36:1 speed synchros for each axis of rotation. Slip rings, rotary joints, and limit switches can be provided in any axis of any positioner.

MICROWAVE COMPONENTS—Scientific-Atlanta also offers a coaxial rotary joint for dc to 16 kmc at speeds up to 2000 rpm, a series of coax to waveguide adaptors, standard gain horns, crystal mixers, transmitting antennas, polarization positioners, model range towers and recorder supplies.

WRITE FOR OUR NEW CATALOG

Ask your Scientific-Atlanta engineering representative for a copy of our new catalog or write directly to the factory.

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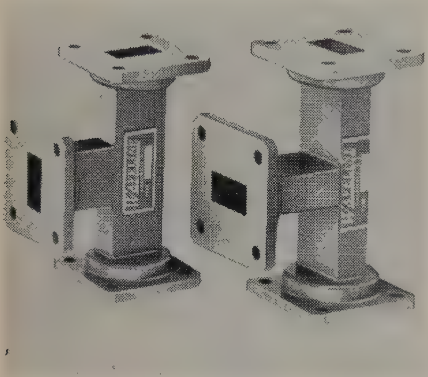
11

Circle Reader Service Card 47

New Products

WAVEGUIDE TEES AVAILABLE IN 16 MODELS



Waveline, Inc., Caldwell, N. J., has available a complete line of series and shunt Waveguide Tees to cover the frequency range of 2.6 to 40.0 kMc. A group of sixteen (16) standard catalog models covers the frequency range mentioned. These series and shunt tees are used extensively for coupling auxiliary microwave devices into a waveguide system. They provide a convenient means of coupling frequency meters, crystal mounts and similar devices into the main transmission line.

The Waveguide Tees are manufactured to the highest degree of quality to assure the alignment of the auxiliary arms and their perpendicularity to the main waveguide. In the series tee, the auxiliary arm is mounted on the broad side of the waveguide. In the shunt tee, the junction is made on the narrow side of the waveguide. Precision manufacture of these items provides optimized VSWR characteristics over the full waveguide frequency range.

Circle Reader Service Card 101

— *m w j* —

MICROWAVE ASSOCIATES ADDS TO ITS LINE OF WAVEGUIDE SWITCHES

A new addition to its line of high-speed, all-solid-state waveguide switches for microwave applications has been introduced by Microwave Associates, Inc., Burlington, Mass.

The MA-3470 2X1 switch is a compact unit for applications in which ultra-fast switching (typically 2 nanoseconds) combined with small size, long life, light weight, and all-solid-state reliability is desired.

The switch is available as a single-pole, double-throw unit for operation at X-band (9200 Mc to 9600 Mc). Other units of this design are also available at greater frequency ranges. One advantage of the MA-3470 2X1 is the low driving power required (approximately 75 milliwatts).

Insertion loss in the "closed" position is 4.5 db (maximum), and isolation of 60 db (minimum) is provided in the "open" condition. The switch will handle 150 watts peak power, and up to 4 watts CW.

Circl Reader Service Card 102

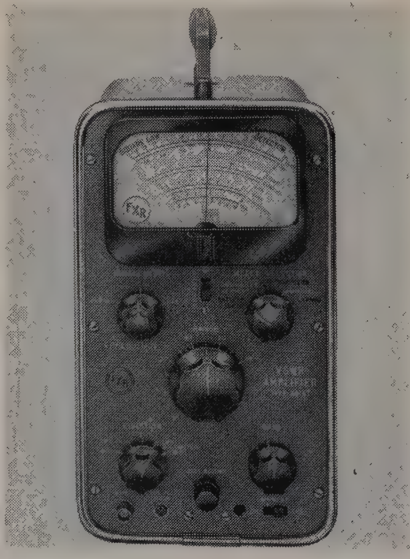
— *m w j* —

FXR INTRODUCES STANDING WAVE AMPLIFIER

A portable transistorized Standing Wave Amplifier has just been introduced by FXR, Woodside, N. Y., a division of Amphenol-Borg Electronics Corp. Its ±0.05 db accuracy holds true for both the full scale meter movement and for each 5 db step on the range switch. The specially designed meter and linear amplifier give a full scale maximum error at 5 db of only ±0.05 db.

The B813T is designed for use on battery power for applications in the field where power is not available, or in the laboratory where line noise might cause inaccuracies in measurement. However, where power is available the unit can be operated from the line in the normal manner.

Calibrated range of the B813T is 75 db. Normal, expanded and compressed meter scales are provided and can be used interchangeably without the need for readjustment of the gain control.

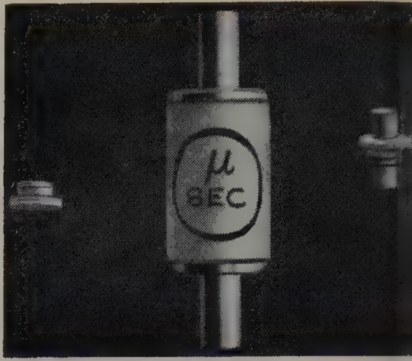


The B813T has special circuitry for bolometer protection and a meter display for bolometer resistance checking and current adjustment. Other features of the B813T include controls and circuitry for selective meter damping, bandwidth, frequency selection and peaking, range adjustment in 5 db steps, battery voltage checking and self-contained charging. Price of the B813T is $285.00 complete with rechargeable battery. Delivery is 60 to 90 days.

Circle Reader Service Card 103

— *m w j* —

VARACTORS AVAILABLE IN CARTRIDGE, "PIN," "PILL" PACKAGES



Micro State Electronics Corp., Murra Hill, N. J., has announced availability o Gallium Arsenide varactors in the doubl ended cartridge package and the coaxial "pin" package, as well as in the standar "pill" package. Applications for the unit include parametric amplifiers, harmoni generators, and microwave switches. Cut off frequencies up to 150 kMc are fea tured, with Q measured at minus 2 volt and 10 kMc. All units are of the diffuse junction mesa structure. All types featur extremely low leakage at the 6 volt max mum working voltage.

The types are MS-262 through MS-26 (pill package); MS-2501 through MS-250 (coaxial pin package); MS-3012 throug MS-3067 (double ended cartridge pack age).

Availability is one to four weeks, de pending upon type.

Circle Reader Service Card 104

— *m w j* —

COMMERCIAL ATC L-BAND TRANSPONDER TEST SET MARKETED BY KEARFOTT

A commercial ATC L-band transponde test set, eliminating the need for multi-i vestment test set-ups, is now being ma keted by Kearfott Division of Gener Precision Inc., Van Nuys, Cal.

The versatile test set, in conjunctio with a suitable oscilloscope, complete checks out any transponder — two puls three pulse, or combinations — built i accordance with ARINC 532C. Throug amplitude control of each pulse in th interrogation train, the unit also check out the side lobe suppression features o the system.

The set simulates all ATC Beacon an Military interrogation modes, simulat two or three-pulse interrogation with sid lobe suppression, and is compatible t ARINC 532C specification.

Circle Reader Service Card 105

— *m w j* —

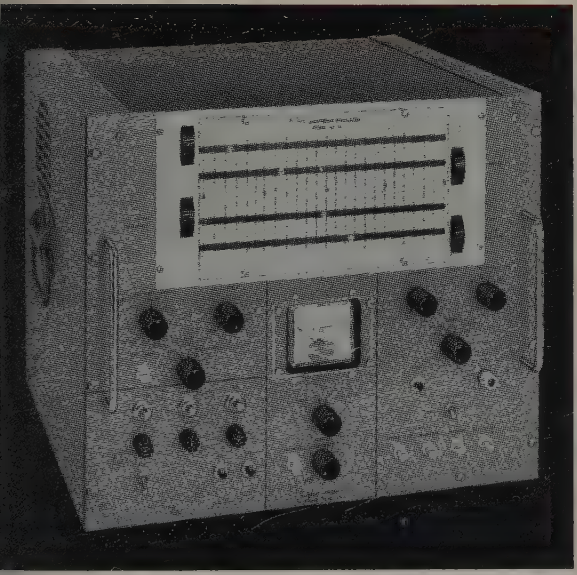
(*Continued on page 98*)

Microwave Sweep Oscillators with FLAT OUTPUT

NEW in Alfred Series 620 Oscillators:

• BUILT-IN FEEDBACK LEVELER

Holds power output constant to ±¾ db over these ranges ... 1 to 2, 1.4 to 2.5, 2 to 4, 4 to 8, 7 to 11 Gc. Feedback Leveler unique in holding output variation to approximately ±0.1 db over any 100 Mc interval. Feedback method makes RF flatness independent of RF level or microwave tube aging. Components being developed for leveling above 11 Gc.



Alfred Model 623BK Microwave Oscillator, featuring built-in eveler, drift less than ±.02% per hour, adjustable frequency markers and Quick Look Readout.

• SYMMETRICAL NARROW BAND SWEEP

Up to ±5% of band width; about any center frequency. A significant time saver for component testing.

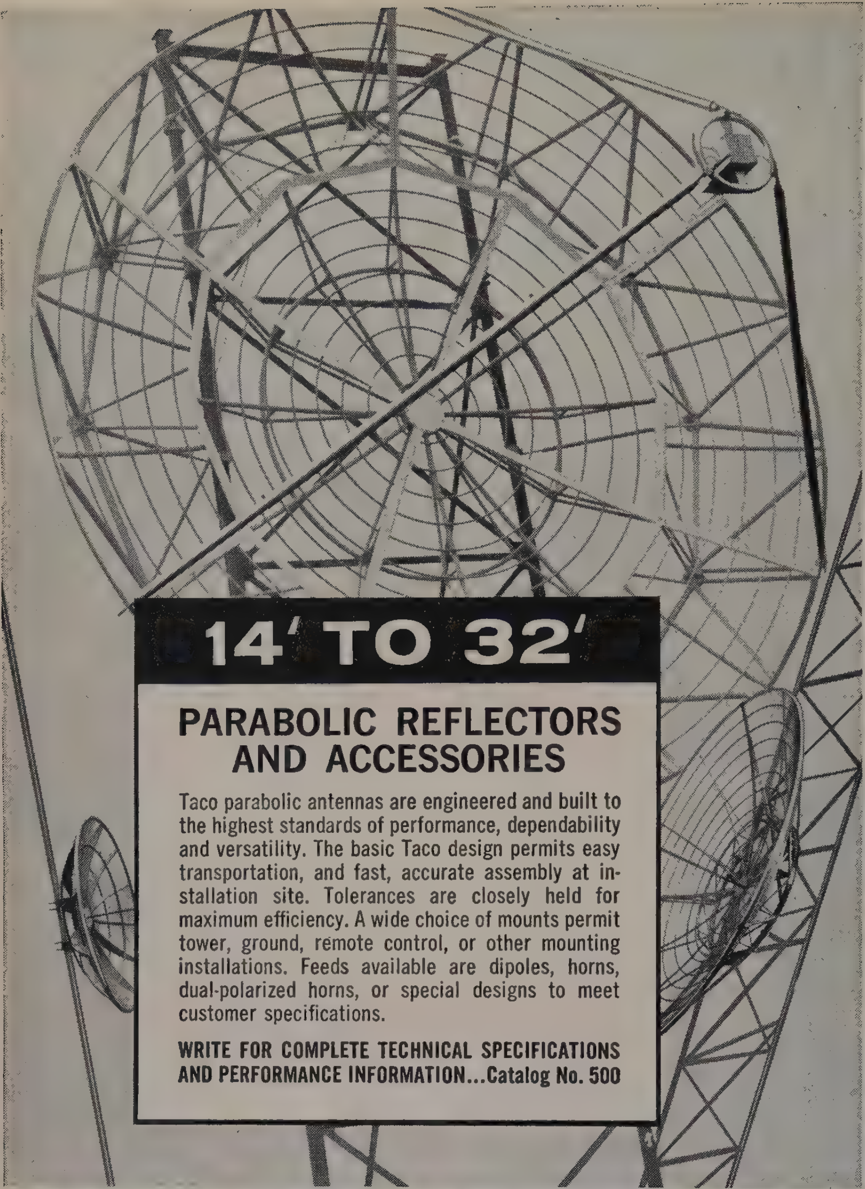
PLUS ALL THESE FEATURES, STILL EXCLUSIVE WITH ALFRED

- **Drift** — less than ±0.02% per hour.
- **Residual FM** — less than 0.0025% peak.
- **Adjustable Frequency Markers** — time-saving indicators of band limits or intermediate frequency values.
- **Quick Look Readout** — shows frequency range, markers and sweep time at a glance.
- **Ten Frequency Ranges, 1 to 26 Gc** — covering 1—2; 1.4—2.5; 2—4; 4—8; 6.5—11.5; 8—12.4; 8.2—12.4; 10—15.5; 12.4—18; 15—22; 18—26.5 Gc. (Internal leveling 1 to 11 Gc only.)
- **0.5 microsecond rise and fall response to AM** — equivalent to a 2 megacycle band pass.
- **Frequency accuracy** ±1% unswept or swept.
- **Direct coupled external sweep connection** — response dc to 10 kc. Ideal for external frequency programming.

GET **COMPLETE** DETAILS — Alfred's policy is to publish specifications — not to withhold them. All specifications are guaranteed as stated. For detailed information on Series 620 oscillators, contact your Alfred engineering representative or write to:

ALFRED ELECTRONICS

3176 Porter Drive, Palo Alto, California • Phone: DAvenport 6-6496



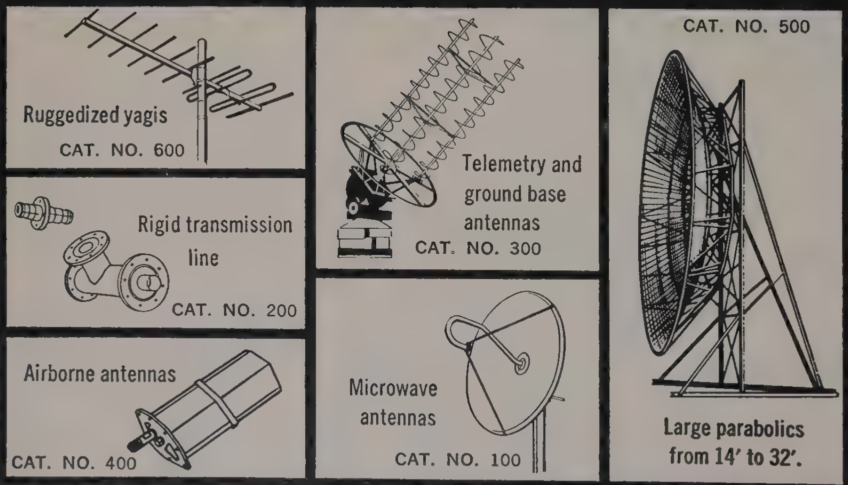
14′ TO 32′

PARABOLIC REFLECTORS AND ACCESSORIES

Taco parabolic antennas are engineered and built to the highest standards of performance, dependability and versatility. The basic Taco design permits easy transportation, and fast, accurate assembly at installation site. Tolerances are closely held for maximum efficiency. A wide choice of mounts permit tower, ground, remote control, or other mounting installations. Feeds available are dipoles, horns, dual-polarized horns, or special designs to meet customer specifications.

WRITE FOR COMPLETE TECHNICAL SPECIFICATIONS AND PERFORMANCE INFORMATION...Catalog No. 500

TACO PRODUCTS



Write for Catalog . . . Defense & Industrial Div.

TACO

TECHNICAL APPLIANCE CORPORATION, SHERBURNE, NEW YORK
Area Code 607 • Telephone OR 4-2211

New Products

(*Continued from page 96*)

RCA DEVELOPS SEMICONDUCTOR MICROWAVE SWITCH

The development of a semiconducto microwave switch for C-band application was announced recently by RCA's Aerospace Communications and Controls Division, Defense Electronic Products, Bur ington, Mass.

The switch, developed under the sponsorship of the Advanced Research Projec Agency, Department of Defense, has an average power handling capability of tw watts at the design frequency of 558 megacycles, with an insertion loss of le than 2 decibels from 5000 to 5900 Mc.

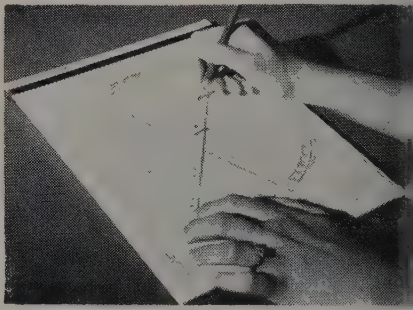
Isolation is greater than 50 decibel over the same range, and rise and fal times of the output pulse are less than 0. microseconds.

The RCA switch, having passed al MIL-E-5400 environmental tests, presently is available for C-band application only. However, models capable of operating at other frequencies are under development. Use of the switch as an electronically controlled attenuator also i being considered.

Circle Reader Service Card 106

— *m w j* —

MEGA-PLOTTER USED WITH SMITH CHARTS



The Mega-Plotter, a new plexigla plotting board designed for use wi standard size Kay Smith Charts ($8\frac{1}{2}$ inc es x 11 inches), has been announced b Kay Electric Company, Pine Brook, N. J manufacturers of precision electronic te and measuring equipment.

The unit also accommodates other typ of polar reflection charts of equal or sma ler radius and is useful for plotting o reading out data from polar antenna radi tion diagrams.

The primary function of the Mega-Plo ter is to provide maximum convenien when recording laboratory data or whe solving transmission line problems on Smith chart. With it, answers are foun more speedily, more accurately, and mo neatly.

Made of opaque white plexiglass, th Mega-Plotter is provided with slide an scratch proof rubber feet for desk bench-top use in the office or laborato

Circle Reader Service Card 107

— *m w j* —

(*Continued on page 100*)

Circle Reader Service Card 49

WX4675
WX4450

new pulse tubes for better definition in high power radar systems

Westinghouse offers two new High Vacuum Switch Tubes for pulse modulator service in radar systems: The WX 4450—highest power tube in the industry—is a 37 megawatt triode for very high voltage at high current. The WX 4675 delivers high voltage at medium current. These are two of a line of tubes developed to meet the latest military radar requirements. For more information, or application engineering assistance to solve your specific problems, write on your company letterhead to: Westinghouse Electric Corporation, P.O. 284, Elmira, N.Y. *You can be sure . . . if it's Westinghouse.*

Examples of Westinghouse high vacuum switch tube capabilities

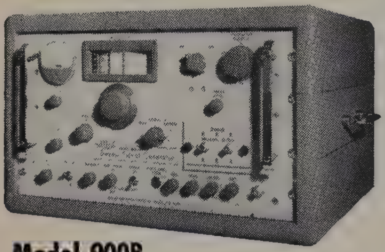
	WX 4450	**WX 4675**
D.C. plate voltage	80KV	75KV
Peak plate current	600 Amps @ .01 duty	200 Amps @ .01 duty
	up to 1400 Amps special applications	up to 400 Amps special applications
Peak Power	37 megawatts typical, up to 90 megawatts on very short pulse width, low duty	14 megawatts typical, up to 26 megawatts on very short pulse width, low duty

Westinghouse

JERROLD®

SWEEP GENERATORS

NEW!

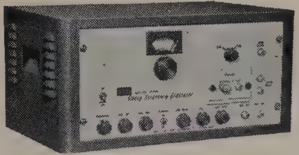


Model 900B

Very narrow to very wide sweep widths in one sweep SIGNAL generator

$1980.00

Unusual stability in sweep widths from 10 kc to 400 mc. Frequency range 500 kc to 1200 mc. Built-in crystal-controlled harmonic markers, direct coupled scope pre-amplifier, and attenuators. The ultimate instrument for your IF-VHF-UHF requirements.



Model 900A

Wide-band sweep generator

$1260.00

Center frequency: VHF, 0.5 to 400 mc; UHF, 275 to 1000 mc. Sweep widths from 100 kc up to 400 mc. Flatness: ±0.5 db over widest sweep.

Model 707

Ultra-flat sweep generator

$795.00

Featuring ±5/100 db flatness; plug-in oscillator heads*; variable sweep rates from 1/min. to 60/sec.; all electronic sweep fundamental frequencies; sweep width min. of 1% to 120% of C.F.

*Heads available within the spectrum 2 to 265 mc. Narrow-band heads on request.

For applications bulletin and complete catalog (including wide-band comparators, precision attenuators and accessories), write:

JERROLD® ELECTRONICS CORPORATION
Industrial Products Division, Dept. ITE-119
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Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N. Y. 16, N. Y.

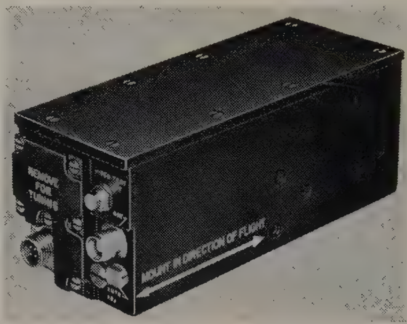
Circle Reader Service Card 77

New Products

(*Continued from page 98*)

GENERAL INSTRUMENT ANNOUNCES RB-200 C-BAND RADAR BEACON

General Instrument Corp., Hicksville, L. I., N. Y., announces the RB-200, a lightweight, solid-state, subminiature C-band Beacon designed for operation as a tracking device to assist radar operators to follow and identify "in-flight" missiles, drones, aircraft or space probes at distances greatly exceeding the normal reflective path of a ground radar.



The beacon consists of a single package measuring 2½ inches x 2½ inches x 7 inches and weighing less than four pounds. The highly compact unit contains a three-cavity preselector which incorporates an integral duplexer and video detector, a broadband video amplifier, decoder, modulator and power supply. The total volume of the unit is 44 cubic inches. Silicon solid state active elements are utilized throughout with the exception of a planar triode transmitting tube.

The principal electrical sections of the beacon include a transmitter capable of emitting a power output well in excess of 10 watts, and a receiver which has a sensitivity which exceeds —45 dbm. The beacon is capable of operation over the frequency range of 5400-5900 Mc. Beacon delay variation with signal level is extremely low thus permitting very accurate range tracking.

Power for the beacon may be switched from an external power source to an internal 6.5-7.5 volt battery by a self-contained relay. The operational life of the internal battery exceeds 30 minutes. The unit is constructed to withstand the extreme environmental conditions encountered during air and space operation.

Circle Reader Service Card 108

— *mwj* —

TWIN TETRODE TUBE PROVIDES 3 DB POWER OUTPUT IN 0.7 SECOND

Amperex Electronic Corp., Hicksville, L. I., N. Y., announces the type 7983, a miniature twin tetrode incorporating a revolutionary new type fast warm-up directly-heated ribbon cathode that provides 3 db power output in only 0.7 second.

It is designed to eliminate standby drain and thereby also reduce heat dissipation in hybrid mobile and portable communications equipment. The 7983 can be use as a power output amplifier, driver frequency multiplier.

The ribbon cathode structure resembl a single folded wide oxide coated stra This arrangement results in considerab less cathode inductance, than in V shap cathodes. This, in turn, minimizes dri power requirements. RF performance comparable to that of indirectly heate cathodes.

The cathode is especially suited for u with PUSH-PULL dual tetrodes becau its structure makes it possible for oppo ing grids to be completely shielded (ele trically opaque) from one another. Th new Amperex cathode is also more rugge than conventional ribbon cathodes.

The cathode voltage is only 3.15 volt so that compatible and equal gain is mai tained over the entire cathode surface.

The type 7983 provides 16 watts pow output at 200 Mc under ICAS condition The tube has been neutralized internall for frequencies up to 200 Mc. In all oth respects, the 7983 is similar to the typ 6360.

Circle Reader Service Card 109

— *mwj* —

MICROWAVE CRYSTAL BOOSTE PROVIDES 40 DB GAIN

The Model Q 11 microwave crys booster, a highly stable, distortion-fr wide-range amplifier offering increas sensitivity of oscilloscopes, voltmete standing wave amplifiers, power mete etc., is being manufactured by Quan dyne, Woodland Hills, Cal.

The flat frequency response makes t unit usable for audio, ultrasonic, or e tremely low rf signal measurements.

The Q 11 is an amplifier which can used for increasing outputs of microwa crystals. It has many applications, is ru gedized, and essentially displays flat f quency response and ultra low-noise cha acteristics for use in very weak sign areas.

Provided with an on/off switch, a complete with flexible cable and BN fittings, it is simply put into a video li (directly following the crystal) for 40 gain.

Circle Reader Service Card 110

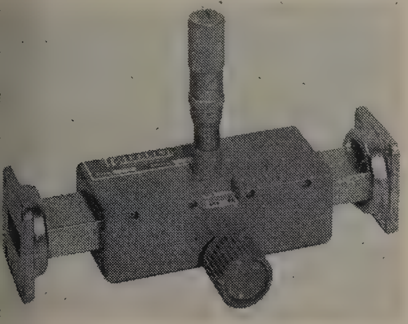
— *mwj* —

VAVEGUIDE SLIDE SCREW TUNERS MINIMIZE VSWR

Waveline Inc., Caldwell, N. J., offers a omplete line of waveguide slide screw iners to cover the frequency range of .85-40.0 kMc.

The complete series, a group of six tandard catalog models, is designed for ninimizing VSWR values in a waveguide ransmission system. The tuners are prinarily used to match various microwave evices and to determine the position and nagnitude of matching structures of new evices being designed in the laboratory.

The slide screw tuners consist of a secion of precision waveguide, slotted lon-



gitudinally in the center of one broad vall, and an accurately constructed cariage, which supports the probe assembly. he carriage is mounted on the waveguide ection and is varied longitudinally along he waveguide by means of a helical rack nd pinion mechanism.

Complete shielding of the waveguide lot is achieved at all times and VSWR alues of 20 to 1 or higher can be reduced o 1.02 without introducing appreciable nsertion loss. Sufficient longitudinal traxel is provided in each unit to assure any lesired phase shift.

Circle Reader Service Card 111

— *m w j* —

ANTI-STICK AGENT PRODUCED IN LARGER PACKAGE

Fluor-Glide, the "Teflon"-like lubricant nd anti-stick agent produced by Chemlast, Inc., East Newark, N. J., is now vailable in a larger, more economical erosol package to meet the large quanity applications prevalent in industry toay, the Company has announced.

The new package contains a full sixeen ounces of this all-purpose Fluorocaron Product, and offers a 25 per cent avings over the six ounce package now n the market.

Fluoro-Glide consists of micron-size articles of a fluorocarbon polymer and an dhesion promoter which combine to form tenacious, low-friction, dry film when prayed on a substrate.

The polymer resists virtually all solvents nd chemicals and withstands temperaures ranging from cryogenic to 500° F vithout deterioration, while imparting a oefficient of friction as low as .07

Circle Reader Service Card 112

— *m w j* —

(*Continued on page 102*)

KEEP ON THE RIGHT TRACK with ANTLAB Tracking Systems

ANTENNA TRACKING PEDESTAL (right) MODEL 7625-20W, PRICE $24,570. More than 40 designs available in totally-enclosed pedestals.

SERVO-CONTROLLER (above) MODEL 3012. Modularized console provides great flexibility of use, easy maintenance.

Years of experience have provided ANTLAB with the engineering know-how to track aircraft, missiles, rockets and satellites accurately and dependably. ANTLAB systems give exact positioning, high acceleration, instant response and smooth operation.

Combining **totally-enclosed** antenna pedestals and advanced servo-controllers, ANTLAB produces tracking systems with built-in reliability. These systems are rugged and versatile and require minimum maintenance. The unique designs incorporate many safeguards to eliminate or greatly reduce downtime, wasted professional time, and other results of costly failures during operational procedures or tracking tests.

When it's time to specify tracking systems, keep on the right track by specifying ANTLAB.

ANTLAB Antenna Range Instrumentation includes: Servo and electro-manually controlled antenna test mounts, tracking systems, model support towers, microwave receivers, pattern recorders, pattern integrators, boresight systems, antenna position indicators, fork-controlled oscillators, anechoic chambers, radome mounts, source positioners, etc. Send for catalog A-161.

ANTLAB, Inc.

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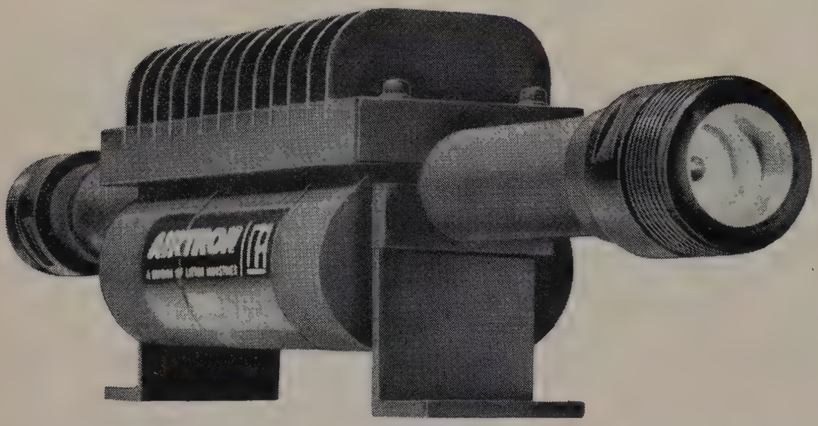
Circle Reader Service Card 95

ONE
WAY



STREET

This particular Airtron ferrite isolator is a high-power broad-band coaxial unit. We make these and many other one-way streets for errant energy in a very broad variety of mechanical and electrical characteristics: many of them are from stock. Because we tailor and produce our own ferrite materials in our Advanced Devices Laboratory to meet special requirements, we can custom build for you with nominal lead time.

Here are condensed specifications for the isolator pictured:

Isolation	15db minimum.
Insertion loss	0.8db maximum over 20% bandwidth. (Can also be made to cover 50% bandwidth for ECM or CCM applications).
Power handling capacity	400 watts *average*. CW(Air cooled).
Input VSWR	1.12 maximum.
Frequency	S-Band or L-Band.
Material	Aluminum.
Line size	⅞-inch coax.
Connectors	L/T both ends, gender optional.
Length overall	13.85 inches nominal, S-Band. 16.84 inches nominal, L-Band.
Weight	3.50 lb. maximum, (S-Band unit).
Ambient Temperature	—20° to 100°C, (L-Band unit).

We invite your inquiry for additional information on Airtron's comprehensive line of ferrite isolators.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

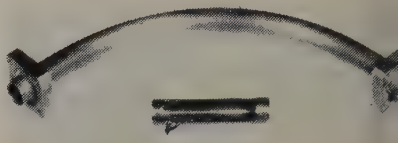
AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N. J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N. J.

Circle Reader Service Card 51

New Products

(*Continued from page 101*)

TRG FABRICATES SIMPLE, COMPLEX BENDS



TRG, Inc., Microwave and Antenna
partment, Somerville, Mass., announ
that they are now fabricating simple
complex bends in millimeter-band circul
waveguides for operation in the low l
TE_{01} mode. The waveguide bends
made by first corrugating the inside
lengths of straight copper waveguide
then bending them to the desired sha
A typical 90° bend at 70 kMc has a
radius, and 0.3 db loss.

In a recently published catalog a co
plete line of circular and rectangul
waveguide devices and ferrite componen
is listed and typical data is described.

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— *m w j* —

PARKER SEAL ANNOUNCES TOP VISUAL QUALITY (T V Q) O-RIN

Parker Seal Company, Culver City, C
has developed a technique in the manuf
ture of O-Rings which enables it to p
duce military O-Rings with superior fin
quality.

The development is a result of resea
for producing the Top Visual Quality
Rings required in many applications
aircraft, missile, and space programs.

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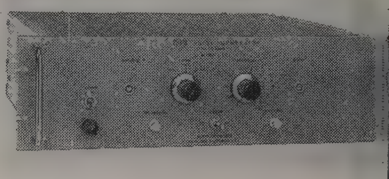
— *m w j* —

PULSE GENERATOR USED FOR MODULATING MICROWAVE AMPLIFIERS



A new pulse generator providing 300
450 volts for loads up to 250 ma pe
specifically designed for modulating mic
wave amplifiers, has been announced
Alfred Electronics, Palo Alto, Cal.

Designated model 5-6826P, Alfre
pulse generator may be internally mo
lated at repetition rates adjustable fr
10 to 10,000 pps or externally trigge
with a 20 volt peak pulse.

Pulse duration is adjustable from 1
12 microseconds; rise and fall time is
ter than .5 microsecond. Sync out puls
provided.

Circle Reader Service Card 11

— *m w j* —

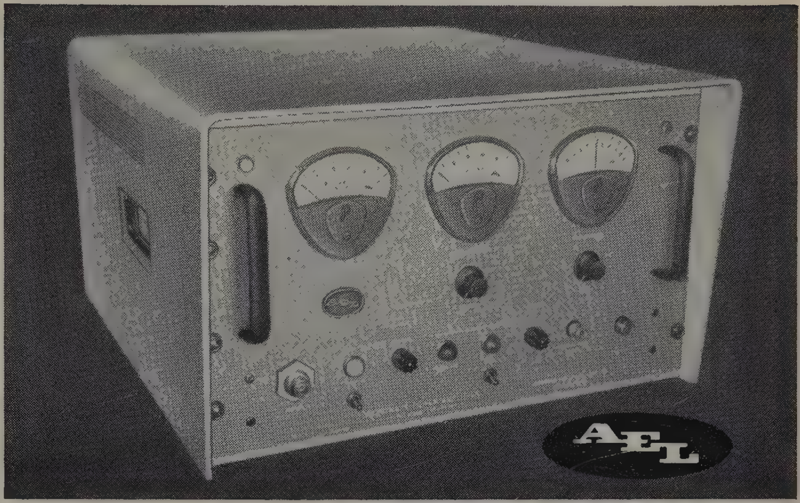
(*Continued on page 109*)

no other line of
MICROWAVE POWER AMPLIFIERS
offers you all these
characteristics

... A powerful statement ... backed up by the AEL TWT Amplifiers described here

- Permanent magnet focusing on all tubes — eliminates need for tube alignment — also eliminates need for heavy solenoids and solenoid ower supplies.
- Ruggedly built for long service under rough onditions . . . heavy gauge aluminum construction.
- Three separate meters for simultaneous indications of beam current, beam voltage and grid voltage.
- Continuously variable gain controls.
- CW, pulsed or AM modulated operation.
- Designed for safety of personnel and tube . . . high voltage interlocks . . . overcurrent and filament protection.

. . . also note characteristics and prices noted below



Two complete lines of TWT Amplifiers from AEL

EXTREMELY BROADBAND
medium power amplifiers

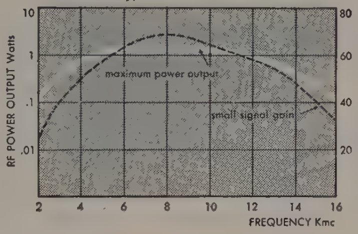
MODEL T601

2 to 16 Gc

total bandwidth

. . . with 1 watt output guaranteed over 5 to 11 Gc . . . with 50 db small signal gain.

Model T601 Typical Performance Characteristics



price: $3,990.

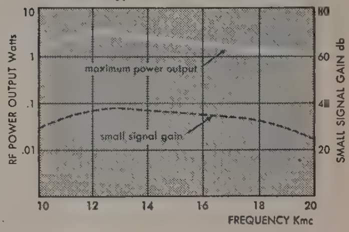
MODEL T602

10 to 20 Gc

total bandwidth

. . . with more than 1 watt output guaranteed from 12 to 18 Gc. Although not guaranteed at this time, 1 watt output may be expected over the entire range 10 to 20 Gc. Gain guaranteed to exceed 30 db from 12 to 18 Gc.

Model T602 Typical Performance Characteristics



price: $4,950.

LOW POWER AMPLIFIERS
Specifications and prices

Model Number	T603	T604	T605	T606
Frequency, Gc	1-2	2-4	4-8	8-12
Min. Pwr. Out, Milliwatts	15	10	10	5
Min. Small Sig. Gain, db	35	35	35	35
rice	$1,795.	$1,795.	$2,100.	$2,100.

MEDIUM POWER AMPLIFIERS
Specifications and prices

Model Number	T607	T608	T609	T610
Frequency, Gc	1-2	2-4	4-8	8-12
Min. Pwr. Out, Watts	1	1	1	1
Min. Small Sig. Gain, db	30	30	30	30
Price	$1,925.	$1,925.	$2,750.	$2,750.

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RAYTHEON
QKK834
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K$_a$-BAND KLYSTRON OSCILLATOR, QKK 834, shown with 90° (above) or 180° (right below) positioning of tuner. **Above photo is actual size.**

New klystrons hold characteristics in grueling aerospace environments

K$_a$- and K-band tubes are tunable from 34.0—35.6 and 23.5—24.5 kMc

Now, Raytheon combines the advantages of small size, extreme ruggedness, thermal stability, and smooth wide-range tunability in a 20mW reflex klystron.

The new QKK 834 for K$_a$ band and QKK 923 for K band are all ceramic and metal tubes with typical electronic tuning range of 110 Mc. The tuner, utilizing a sapphire rod, can be specified for positioning anywhere on the circumference of the resonator at least 90 degrees from output flange (see illustrations above). Write today for detailed technical data or application service to Microwave & Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

QKK 834, QKK 923—
GENERAL CHARACTERISTICS

Power Output	20 mW (nominal)
Frequency	34-35.6*; 23.5-24.5† kMc
Resonator Voltage	400 V
Reflector Voltage Range	—65 to —175V
Temperature Coefficient	± 0.5 Mc/°C
Cooling	convection (no blower needed)
Overall Dimensions	1 5/8 x 1 1/16 x 2 in.*

*QKK 834 †QKK 923

RAYTHEON COMPANY

RAYTHEON

MICROWAVE AND POWER TUBE DIVISION

Circle Reader Service Card 53

Toward Standardization of High-Precision Coaxial Connectors

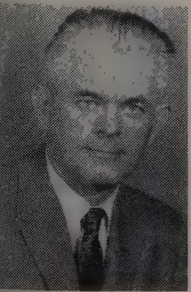
By F. J. TISCHER

Editor's Note—As operating bands have become broader and broader, and frequencies higher and higher, it has been found that the best means of transferring energy from device to device is the coaxial line with its associated fittings. A severe limitation on the use of this means, however, has been the lack of uniformity and precision. With the following editorial and a series of papers, the first of which starts on page 80 of this issue, we highlight activities in the industry currently attempting to deal with this problem.

One problem that faces anyone engaged in high precision microwave measurements is the use and choice of a connector. This usually becomes a distressing problem because of a lack of standardization which, though excusable in the early days of microwave development, is no longer justifiable.

The author remembers how, in 1942, he was forced to develop under emergency conditions a temporary connector for use in his laboratory. In 1947, we had to start again. This time, modifications of standard connectors did the job. Those familiar with my book on microwave measurements(1) have observed the frequent notation: "this instrument is equipped with modified $\frac{7}{8}$ inch or type "N" connectors." At that time (1947), VSWR's of 1.2 and 1.7 of type "N" connectors at 3 and 10 kMc were common figures. Well, we modified the connectors and achieved 1.02 and 1.003 for mated pairs of these two sizes at 3 kMc. The best result achieved at that time was a transition for measurement purposes from $\frac{7}{8}$ inch to type "N", including an impedance transformer from 46.4 to 50.7 ohms. Ten fabricated samples showed a VSWR $<.01$ measured with an error of less than 0.3 per cent of $\Delta z/z_0$(2).

FREDERICK J. TISCHER is chairman of the "Committee for the Standardization of High Precision Coaxial Connectors". He is an associate professor at Ohio State University teaching courses on Microwaves, Electromagnets, Plasmadynamics and Space Communications, and is a research advisor and consultant to government agencies and companies.



Dr. Tischer has been in the field of Microwaves since 1940. He is author of a book "Microwave Measurements" and of numerous articles in the above fields. His contributions in the microwave field include the invention of the Ring Resonator, the H-Guide, the Inductive Probe, and VSWR-meters.

For those unfamiliar with this type of work, two fundamental questions may arise. First, why such a high accuracy, and second, why coaxial structures? The first question can be fully understood only by those who did development work in the field of microwave components. They learned the hard way how difficult it was to compensate for the tremendous number of discontinuities in such a simple-looking gadget as a coaxial transition with two connectors of different sizes on both ends. Each of the very small discontinuities—some of which represent regions with very complicated electromagnetic fields inaccessible to accurate computation—has to be understood and compensated per se. Measurement of the data of these small discontinuities requires the high accuracies.

The second question can be understood more easily, especially by management. Paging through a catalog of waveguide components (e.g., *the microwave journal*, August 1961, pp. 36, 37), it can easily be realized that perhaps 5 different components of the same type with different-size guides, some of which are very bulky, can be replaced by one well-designed coaxial substitute in a coaxial system.

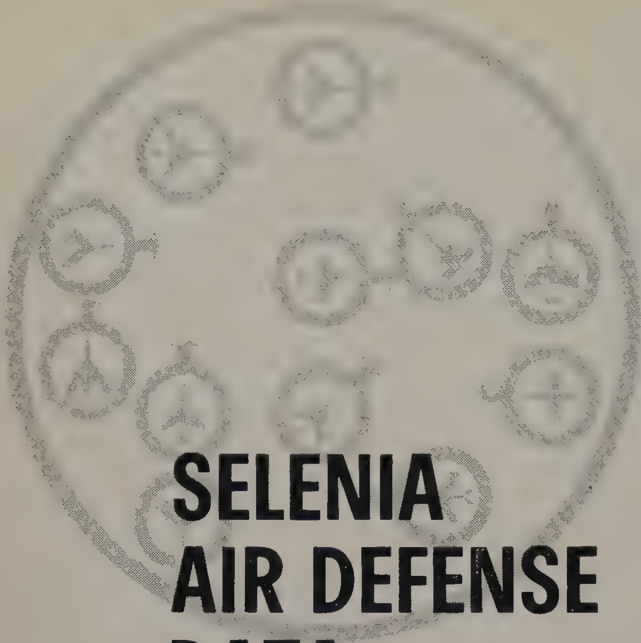
It is self-evident, then, that in standard measurement setups, the errors of coaxial measurement must be at least smaller than the discontinuity reflection and data to be measured, though some clever people know methods to circumvent this requirement. Hence, high precision connectors are necessary to equip high precision instruments needed primarily in laboratory setups and primary and secondary standards. (I do not envision, at present, a man working in a pressurized space suit on the moon making such high precision measurements).

Following this brief discussion of high precision measurements and the corresponding connectors, let us consider the present situation. Because no useful standards for a precision connector exist, extensive and expensive duplication of work occurs. At several places, standard connectors are modified to meet the requirements for precision; elsewhere, new connectors are being developed; the National Bureau of Standards faces the insurmountable task to provide calibration services. It is this undesirable situation which led to the formation of a committee for the standardization of high-precision coaxial connectors during last year's Conference on Standards and Electronic Measurements at the Boulder Laboratories of the National Bureau of Standards.

The committee is composed of members of the N.B.S. and of industry. As formulated at the business session of the committee, June 30, 1961, its purpose is as follows:

> "The final purpose is to recommend high-precision coaxial connectors for laboratory purposes such that

(*Continued on page 106*)



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TISCHER

(*Continued from page 105*)

connectors or data recommended by the committee wi permit the connection of high-precision instruments t each other with errors introduced by the connecto kept to an extreme minimum and with the maximu possible upper limit of the error well known. Th will permit intercomparison of standards among labo atories, including the National Bureau of Standard It is expected that suitable transitions between high precision connectors of various sizes and types will b available but this is not to be considered a goal of th committee.

The committee will specify accurate measuremen methods including tests and environmental conditio to assure connector quality and accuracy of data. With in six months, the committee shall consider for fina approval the first of the high-precision connectors i accordance with the above goals. It is expected tha other connector sizes will follow shortly thereafter.'"

During this past year, the committee, by coordinatin its thoughts and efforts, considerably clarified the step necessary for standardization.

For instance, respondents to a detailed questionnai furnished valuable data about what was needed and ho these needs are now being met in industry and gover ment laboratories. Suggestions for the standardizatio of impedance, sizes, structure and other data were r quested and received.

Another working group under H. Lance of the N.B. made up a list of subjects which have to be studied befo useful standards can be achieved.

A third group headed by R. C. Powel of N.B.S. a ranged the meeting on High-Precision Connectors o June 29(3). At this very successful one-day meetin papers on the following subjects were presented: prec sion connectors, precision and high precision connecto under development, the modification of standard conne tors for improving their properties, and high precisio measurement methods. This was followed by a questio and-answer period and a round table discussion in whic a lively exchange of information was achieved.

All these activities served to collect and to furnish i formation needed in proceeding toward the goal of sta dardization.

Two sizes, 0.75 inch and 0.56 inch, were tentative adopted as inner diameter of the outer conductor f recommendation at an impedance of 50 ohms. A thi size, 0.28 inch, is under consideration to cover the fr quency range up to about 18 kMc. Design structure definitions, measurement methods, and measurement co ditions are being considered, with some related ite already adopted.

Records of the technical meeting, supplemented by th results of the business session, will soon be availab and can be requested from N.B.S.

Also under consideration are a definition of a hig precision coaxial connector and a description of i properties. Theoretically, these properties can be de cribed by the symmetrical scattering matrix of a thre port

$$\begin{vmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{23} \\ S_{13} & S_{23} & S_{33} \end{vmatrix}$$

he two rigid coaxial transmission lines—flexible cables ave not the required accuracy—are two of these ports, ith the surrounding space forming the third. Leakage om the inside to the outside and vice versa is the transission path to the third port. Additionally a basic figure or the overall classification by VSWR or better by z/z_0 in per cent may be needed. Description of the roperties of a "mated pair" already was adopted as a andard.

Other recommendations accepted for a coaxial preciion connector are: The connectors should be sexless to ermit interconnection of all types of components and nstruments without transitions. The connection of inner nd outer conductors should occur in one and the same lane. The design should be such that perfect alignment f the connector pair is achieved with separation of the oupling mechanism from the electrical connector parts. maximum VSWR better than 1.003 for a connector air to 10 kMc is desirable.

The supporting study and evaluation program aptly ummarized by H. W. Lance of N.B.S.(4) deals with echanical and electrical design criteria, materials, mechnical and electrical tolerances, measurement methods, nd adaptors. The evaluation of its results will yield the pper limits of the permissible errors kept at a minimum. These investigations have to be supplemented by an evaluation of the newly developed high precision coaxial connectors.

The study program can be carried out by coordination of research efforts at present already under way and by some additional work which by its nature could be well conducted at universities as thesis work. The information flowing out from these studies will also be of considerable value for the development of microwave components in general.

The whole program has the necessary width to yield well founded standards for these high precision connectors. It is conducted with ideal conditions as a goal. Perhaps the rough reality (and the necessity of compromising) will not permit the achievement of the desired results in all areas. Nevertheless, it can be stated that a reasonably good standardization will be followed by savings in general engineering manpower exceeding by far the investment of efforts in the standardization program.

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2. Tischer, F. J. and Thunquist, D., Kontrollmätning och Justering av 20 st. Overganger mellan 7/8″ och Typ "N" Koaxialkontakter. KTH-FOA Report, Stockholm, Sweden, 1952.
3. Technical Program of the Meeting on High Precision Connectors, National Bureau of Standards Laboratories, Boulder, Colorado, June 29, 1961.
4. Lance, H. W., Study Outlines, File No. 84.50, NBS, March 20, 1961.

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THE ULTRASTABLE MICROWAVE OSCILLATO

as a general-purpose signal source and as a secondary frequency standard.

by BYRON R. YOUNG
Engineer, Instrument Division
LABORATORY FOR ELECTRONICS, INC.

It is well known that an extremely stable microwave oscillator is required as the local oscillator in moving-target-indicating radar systems. In this application, the sub-clutter visibility and cancellation ratio aspects of the over-all system depend largely on reducing and maintaining the peak f-m deviation of the local oscillator to a few cycles per second.

It is not so well known that oscillators of exceptional stability are and should be used in many newer fields. As a result of steadily growing activity in the microwave field and the need to measure with greater accuracy and precision, the excellent characteristics of modern stable oscillators should be fully realized.

In most applications, three basic stability characteristics are required: (1) freedom from residual f-m (short-term stability), (2) freedom from drift (long-term stability), and (3) improved power stability. For LFE's 814-Series oscillators, the residual f-m is down to approximately five parts in 10^8 or better, drift is one part in 10^6, and power stability is ± 0.25 db.

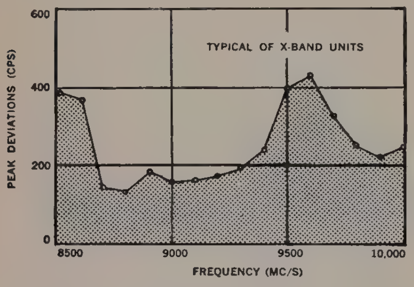


Figure 1

To illustrate the frequency stabilities directly, figure 1 shows residual f-m in cps plotted as a function of output frequency in mc/s at X-band. Most of the residual f-m is noise, a non-periodic function. As might be expected, the principal periodic contribution is from power-line frequencies as shown in figure 2.

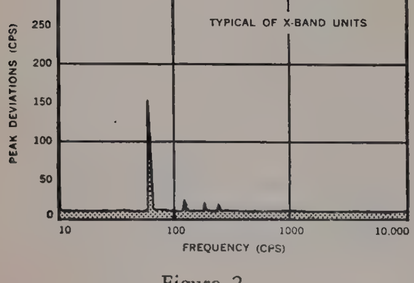
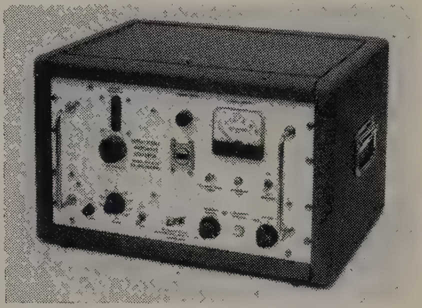


Figure 2

The purity of signal, the power stability, and the small drift enhance measurement accuracy. Wherever high resolution is needed to determine fine detail, the ultrastable oscillators are invaluable. Also, the extremely high signal-to-noise ratio permits measurements at very low levels. The use of these stable oscillators makes measurements possible that otherwise could not be made.



Model 814-X-21

The practical applications for 814 oscillators are becoming more numerous with time. To name a few, they are used as parametric amplifier pumps in radio astronomy; as r-f sources in microwave spectroscopy, in low-noise receiver development, in low-order VSWR measurements; and as local oscillators in high-performance MTI radars and other receiver-like devices. And in any application where the measurement sequence extends over a considerable length of time, the power stability and freedom from drift are particularly appreciated.

For general-purpose laboratory use, ease of use is as important as stability. In this respect, the 814 oscillators are really outstanding. One-dial control is closely approached. The direct-reading tuning dial, illustrated in figure 3, actually controls the dual-mode, invar reference cavity, a precision wavemeter accurate to 0.1 percent of reading. By means of a calibration chart, substantially greater absolute accuracy can be attained.

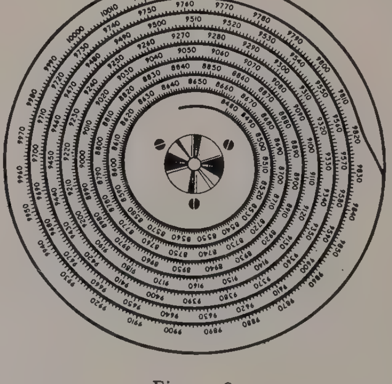


Figure 3

Adjustment is very simple. After setting the frequency dial, the klystron tuning control is adjusted to the point where the stabilization indicator lamp goes out and output is maximized. Should stabilization become l for any reason, the lamp lights as a warn

An 814-Series oscillator can be amplit modulated up to 15% at 1000 cps means of an internal oscillator-modula and at other frequencies by an extern modulator. Higher modulation percenta can be obtained with an external gyrat Also, the output can be frequency modula up to 0.01 percent of frequency.

In addition to its many uses as a gener purpose signal source, an 814-oscillator also used as a secondary frequency standa By means of a transfer oscillator a counter, models of which are commercia available, any frequency can be set into 814 to a high degree of accuracy. Th the drift of an 814 is so small that it c be depended upon for long periods time as a secondary standard. Also, th ultrastable oscillators make excellent exci to drive multiplier chains for the gene tion of much higher frequencies of gr accuracy.

SERIES 814
STANDARD MICROWAVE OSCILLATOR LIN

Oscillator	Frequency in mc/s	Nomin Powe (milliwa
L-BAND		
814-L-9	2000-2500	100
S-BAND		
814-S-1	2500-3050	75
814-S-2	2950-3600	80
814-S-31	3700-4300	1000
C-BAND		
814-C-1	5100-5900	60
814-C-1A	5100-5900	60
814-C-10	5400-5900	200
814-C-31	5925-6425	1000
X-BAND		
814-X-1	8500-10,000	80
814-X-2	9000-10,500	55
814-X-3X	9800-11,200	250
814-X-21	8500-10,000	500
K-BAND		
814-K-21	12,800-14,500	100
814-K-22	14,500-17,500	100
817-K-24	23,000-25,000	40

In addition to the models listed, packag and engineering modifications are availa to meet particular requirements includ those of systems in which an 814 is component. For Bulletin 814, or for parti lar information, write to Mr. Perry Poll at the address below.

If you are also interested in measur frequency stability, ask for a bulletin on Model 5024 Stability Tester.

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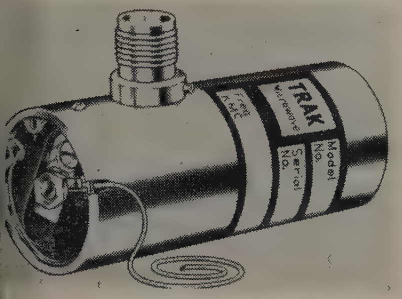
(*Continued from page 102*)

WO SMALL C-BAND MICROWAVE ISCILLATORS PRODUCED BY TRAK



Two small C-Band oscillators are now ailable from Trak Microwave Corp., ampa, Fla.

Type 9127C (CW) is 7/8 inch in diaeter, 2½ inches long and weighs 3¼ unces. It will tune the entire C-Band om 5.2 Gc to 6.0 Gc by adjusting a rew on one end of the C-Band cavity. he power output is greater than 10 mw om 5.4 — 5.9 Gc and greater than 5 mw er the entire band.

Type 2970 (CW) is ½ inch shorter an 9127C (CW) and weighs only 3 unces. Other specifications are identical.

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— *m w j* —

RF PROBE FEATURES TUNING ADJUSTMENT

A completely redesigned RF Probe, featuring an extremely smooth and precise tuning adjustment, has been announced by The Narda Microwave Corp., Mineola, L. I., N. Y.

Designated Narda Model 229B, the new RF Probe is designed for use with all waveguide and coaxial slotted lines that have the standard ¾ inch diameter mounting hole.

The new instrument features a fine wire probe, adjustable in depth over a wide range by a fine-pitch threaded knob. The fine wire probe is actually an extension of the center conductor of a coaxial line which is provided with both shunt and series tuning elements for tuning over the range of 900 to 18,000 Mc. Either standard microwave crystals or Narda N-610B Bolometers may be used and an RF output is also available to enable the unit to be used with microwave receivers or other external detectors.

The new RF Probe is priced at $145; the RF Output (Model 229-427) is priced at $25.

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— *m w j* —

(*Continued on page 112*)

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E-ICING . . . by MARK'S Heated Radomes . . . or use MARK'S unheated radomes . . . stallation stays clean either way.

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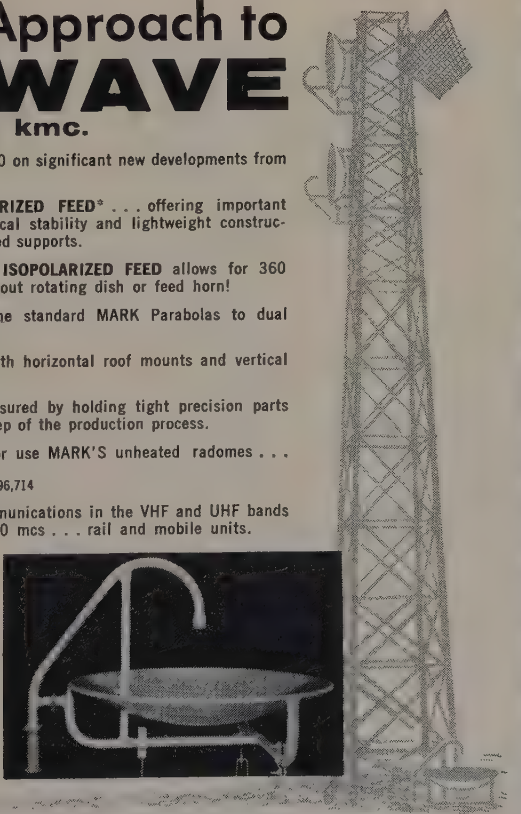
ARK also manufactures antennas for 2 Way Communications in the VHF and UHF bands . . point to point Grid Parabolas for 450 to 2200 mcs . . . rail and mobile units.



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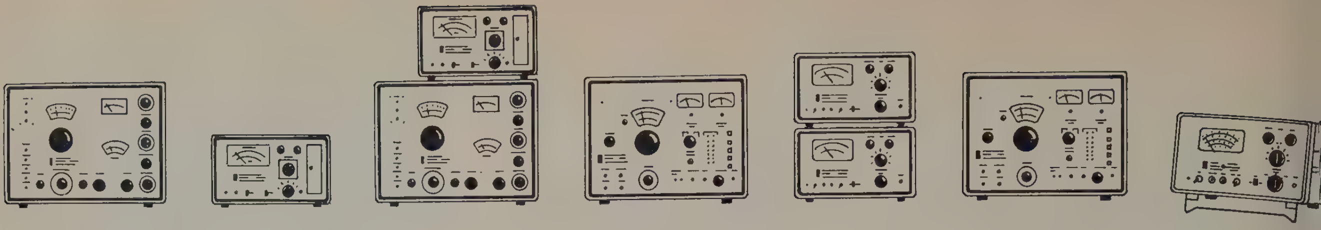

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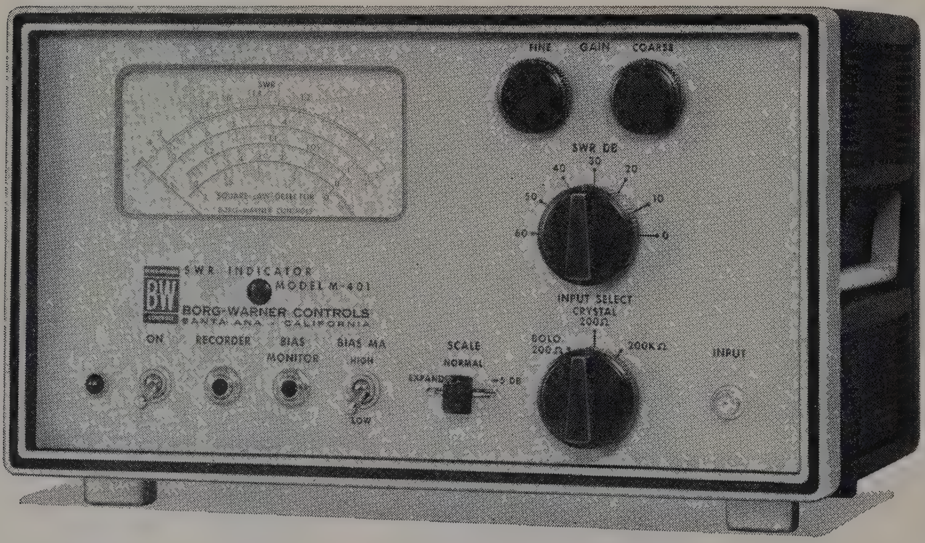
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SCALE
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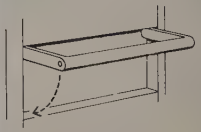

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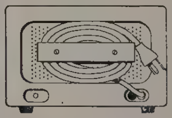

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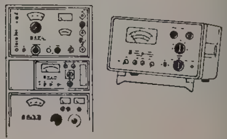

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Table for Determining Cutoff Frequencies For Circular Waveguides

DR. KIYO TOMIYASU
GENERAL ELECTRIC COMPANY
GENERAL ENGINEERING LABORATORY
Schenectady • New York

The following table gives cutoff frequencies for the irst thirty modes in air-filled circular waveguide. The utoff frequency f_c is given by

$$f_c=\frac{\mu c}{\pi D}$$

where:

c=velocity of light, 1.18022 x 10^{10} inches/second

D=diameter, inches

The values of μ are solutions of the proper Bessel functions; these values are tabulated by C. L. Beattie, B.S.T.J., Vol. 37, pp. 689-697, May, 1958. The cutoff frequency in negacycles times the diameter in inches is given by

$f_cD=3756.76\mu$ Mc inch

It should be noted that each mode has an orthogonal legenerate pair, except those modes having a zero for the irst index, e.g., TM_{01}, TE_{01}, etc.

	Mode	f_cD Mc · inch
1	TE_{11}	6,917
2	TM_{01}	9,034
3	TE_{21}	11,474
4	TM_{11}	14,395
5	TE_{01}	14,395
6	TE_{31}	15,783
7	TM_{21}	19,293
8	TE_{41}	19,977
9	TE_{12}	20,029
10	TM_{02}	20,738
11	TM_{31}	23,969
12	TE_{51}	24,102
13	TE_{22}	25,193
14	TM_{12}	26,356
15	TE_{02}	26,356
16	TE_{61}	28,180
17	TM_{41}	28,508
18	TE_{32}	30,111
19	TM_{22}	31,622
20	TE_{13}	32,069
21	TE_{71}	32,225
22	TM_{03}	32,510
23	TM_{51}	32,952
24	TE_{42}	34,872
25	TE_{81}	36,243
26	TM_{32}	36,670
27	TM_{61}	37,328
28	TE_{23}	37,453
29	TM_{13}	38,219
30	TE_{03}	38,219

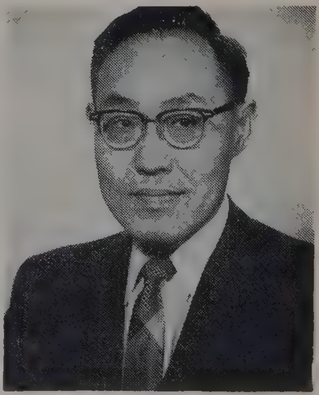
KIYO TOMIYASU was born in Las Vegas, Nevada, on September 25, 1919. He received a BS legree in electrical engineering from the California Institute of Technology in 1940, and an MS degree in communication engineering from Columbia University in 1941. With a Low Scholarship, he studied at Stanford University and then entered Harvard University to continue graduate work on a Gordon McKay Scholarship. He served as a teaching fellow and research ssistant at Harvard, and, after receiving a PhD degree, served as instructor.

In September, 1949, Dr. Tomiyasu joined the Sperry Gyroscope Company as project engineer and in 1952 was promoted to the position of engineering section head for microwave esearch in the Microwave Components Department.

In August, 1955, he became a Consulting Engineer at the General Electric Microwave Laboratory, Palo Alto, California. Five years later he transferred to the General Engineering Laboratory, General Electric Company in Schenectady, New York.

He is a member of the PGMTT Administrative Committee and was chairman during 1960-61. He was editor of the IRE Transactions on M.T.T., during 1958 and 1959 and is currently a nember of the IRE Editorial Board.

Dr. Tomiyasu is a member of the American Physical Society and Sigma Xi.



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2. R. F. Characteristic Impedance 51.0 Ohms
3. Voltage Standing Wave Ratio ....1.2:1 at 3,000 Megacycles
4. Insertion Loss 0.3 DB at 3,000 Megacycles
5. Crosstalk (Interchannel Attenuation) ....60 DB below operating level at 3,000 Megacycles
6. R.F. Voltage Rating 500 volts peak
7. R.F. Power Rating ....100 Watt Avg. at 3,000 Megacycles
8. Operative Life 10,000 Cycles minimum
9. Insulation Resistance ....Greater than 500 megohms at 500 V.D.C.
10. R.F. Connector ....Type BNC (50 ohm) equivalent of UG-291/U
11. Connecting R.F. Cables ....50 ohm coaxial cables with type BNC connector
12. Rotor Non-shorting
13. Circuit Single pole –2 position at 180°
14. Operating Temperature Range ....–55° to +55° centigrade
15. Weight 14 ounces

R. F. COAX. SWITCH
2 5/32
1 1/2
1 3/16
1 15/32
2
1
21/32
1 15/16
3 1/8
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New Products

(*Continued from page 109*)

SYLVANIA ANNOUNCES X-BAND MICROWAVE MIXER DIODE

The availability of a new high burnou X-band silicon microwave mixer diod which will withstand more than twice th spike energy of its closest counterpart ha been announced in Woburn, Mass., b Sylvania Electric Products Inc.

Marvin E. Groll, product sales manag — microwave diodes for Sylvania's Semi conductor Division, said the new uni designated type D4181, is identical mech anically and electrically to type 1N23C which it replaces directly in application involving high incident RF energy. How ever, with a spike energy rating of fiv ergs, type D4181 is "far more rugged tha its two-erg counterpart," he added.

Mr. Groll said D4181 units are present ly available from franchised Sylvania semi conductor distributors.

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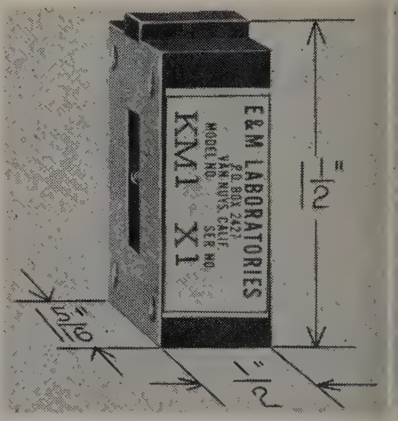
— *m w j* —

ISOLATOR SERIES ADDED TO E&M LINE



E & M Laboratories, Van Nuys, Ca announces the addition of a series of mi iature microwave Ku-band isolators t their standard line. All units in the seri are ½-inch long and weigh less than 1½ ounces, the shortest and lightest know isolators in this frequency band. A sele tion of isolation and bandwidth characte istics is offered for special customer r quirements. Exhibited in the entire seri are the following additional specification a nominal insertion loss of 0.3 db, isol tions up to 25 db, a temperature range o —40°C to +85°C, and capability of op erating in close proximity to external ma netic fields.

The primary uses of these isolators a in parametric amplifier designs where lo insertion loss is important and in mini ture microwave systems. For retrofit o existing systems, these units are ideal sin they are of the in-line field displaceme type which do not require a correcti waveguide twist and since the short leng simplifies location problems.

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— *m w j* —

(*Continued on page 115*)

A WORLD WIDE STANDARD POLARAD FIELD INTENSITY RECEIVERS

MODEL FIM-2

1,000 to 10,000 mc

Hundreds of Polarad Calibrated Field Intensity Receivers are in use today throughout the world. **Why?**

...because the FIM series, in production since 1956, offers ±1db accuracy because of its self-contained signal generator.

...because the Model FIM-2 is the only single unit microwave system capable of measuring rf interference and susceptibility. It has been designed for measurements in accordance with all military RFI specifications.

...because the FIM-2 is an integration of two instruments in one, it is always available in your laboratory as either a sensitive microwave receiver or an accurate signal generator.

...because UNIDIAL® tunes both the receiver and signal generator simultaneously; and, the front-panel meter indicates average, peak, slide-back peak or quasi-peak value of rf signals, the Polarad of FIM-2 is the most convenient instrument in use today.

ODEL FIM-2 FEATURES

EQUENCY RANGE: 1 gc to 10 gc in 4 tuning units; 2 more tuning units under development will extend frequency to 20 gc.
EQUENCY DIAL ACCURACY: ±1%
NSITIVITY: 20 microvolts
XIMUM RF INPUT: 3 volts
PULSE BANDWIDTH: 5 mc
AGE AND SPURIOUS RESPONSE REJECTION: 60 db
TPUTS: Video, audio, recorder
NAL GENERATOR OUTPUT POWER: 0.223 volts to 5 micro-
s (for susceptibility measurements)
NAL ATTENUATION: 0 to 80 db in 1 db steps

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RANGE OF LINEARITY: 60 db with AGC.
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VIDEO BANDWIDTH: 2 mc.

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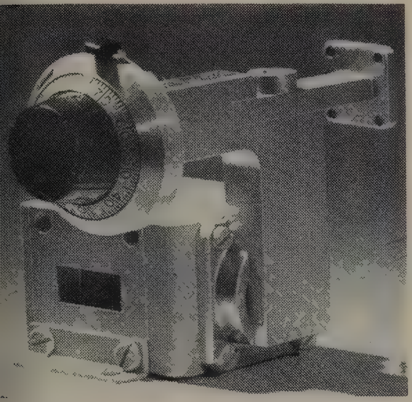
(*Continued from page 112*)

TEXAS INSTRUMENTS DEVELOPS X-BAND PARAMETRIC AMPLIFIER



Single-knob tuning over a 1.1-Gc range rovides operational simplicity in a non-legenerate X-band parametric amplifier leveloped at Texas Instruments, Dallas, Tex. Intended primarily for radar appli-ations, the amplifier can be used to ex-end the range of existing radar equip-nent or incorporated in advanced radar lesigns.

Important performance features are a .5-db system noise figure, including cir-ulator loss and normal second stage con-ribution; 30-Mc bandwidth at 15-db gain; nd a fixed K-band pump frequency with ess than 50 milliwatts of pump power re-uired.

The amplifier utilizes a single TI gallium arsenide varactor diode in a broadband circuit that gives stable gain characteristics and requires minimum tuning adjustment.

Circle Reader Service Card 120

— *m w j* —

TEN TYPES OFFERED BY PACIFIC SEMICONDUCTORS

Ten new High-Q Varicap (voltage-variable capacitors) have been announced by Pacific Semiconductors, Inc., Hawthorne, Cal.

The new types are from the same parameters as the premium grade PC117, PC116 and PC130 Varicap but are offered at a substantially lower price.

The ten types are designated PC122, PC114, PC129, PC128, PC113, PC133, PC126, PC124, PC115 and PC141 covering the capacitance range from 47 pf to 6.5 pf respectively. Q values range from 50 to 125 and working voltages from 25 to 100V.

Like the premium grade High-Q Varicap, the new types offer the designer a broad potential in the development of frequency multipliers, parametric amplifiers, AFC, electronic tuner and other circuits.

Prices range from $5 to $7 each in quantities to 999 units.

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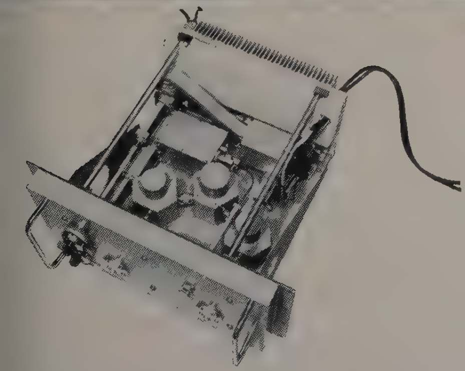
— *m w j* —

(*Continued on page 118*)

New Micromega Paramp Is Tunable from 750 to 1000 MC!

Micromega now introduces the first UHF parametric amplifier in the 750-1000mc frequency range that is tunable without additional plug-in units and sub-assemblies. What's more, it's tunable in a matter of just minutes!
Specifications: noise figure, as low as 2db; gain, 17db; band-width, 10mc; input and output impedance, 50 ohms.
For excellent stability in unattended operation, simply house this precision paramp in a thermoelectrically stabilized temperature enclosure.
Offered from UHF to X-Band, with or without mixer and IF pre-amplifier, in single and production quantities, Micromega parametric amplifiers are used widely in radar, telemetry, and troposcatter and satellite communications systems. Literature and detailed information are available from the company.



Model 1000 UHF parametric amplifier

Micromega Corporation

4134 Del Rey Ave., Venice, Calif., EXmont 1-7137

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HOW TO RUN AN ELECTRONICS COMPANY – INTO THE GROUND

"CARRYING OUT THIS PROCEDURE . . . IS NOT AS SIMPLE AS IT MIGHT APPEAR."

By PROF. DR. Z. X. GADFLY

I. INTRODUCTION

The management personnel of some electronics companies have found that their profits can readily disappear in spite of continuous increases in military electronic expenditures. To the dismay of many stockholders and bankers, these losses are often largest just when total sales are increasing rapidly. Although this situation might appear disastrous by ordinary financial standards, a few astute managers have discovered a modern alchemist's trick for turning large losses on a high sales volume into profits. Thus, with a slight assist from present tax laws the manager of a successful failure can often arrange to have his company bought up on highly favorable terms by another company whose profits (after taxes) can be greatly enhanced by the acquisition of a large tax loss.* Consequently, there is a great deal of interest at present in the most efficient means for ruining an established company.

In our role as management consultants, we have scientifically analyzed this problem and discovered several interesting solutions. For example, (1) that Gresham's law in Economics has a counterpart in destructive personnel relations, namely that an abundance of mediocre people tends to drive intrinsically valuable people out of a company, (2) that by properly bidding on certain contracts, a large backlog of prestige-building work can be obtained with a subsequent staggering loss of profits, (3) that benevolent personnel programs can readily be made to backfire, and (4) that properly applied incentives, both negative and positive, can disrupt the constructive efforts of key personnel and nearly elimina all productivity. Some of our findings are explained more detail in the following sections.

II. MEANS FOR RUINING A SUCCESSFUL COMPANY

A. By Proper Personnel Management

The mainspring of a successful electronics company formed of key personnel who alone are largely respon ble for the sales, technical supervision, and manageme of a large dollar volume of military electronics contrac In many cases these key personnel are also responsi for recruiting their own top level employees, establishi and maintaining contact with prospective custome planning future areas of work, controlling their ove head expenditures, etc. These key personnel primar require only financial support from the company a with this support they actually run successful business within the company facilities. They must, therefore, considered the prime targets of any successful ruinati scheme.

Since these key personnel can readily establish a co pany in almost any field, even those in which they ha never worked before, they are highly sought after a constantly bombarded with tempting financial offe Also, since they mainly require only financial backi and facilities, risk capital is often made readily accessi to them on highly favorable terms to induce them start companies of their own. Thus, in order to remo these key personnel from an established company quickly as possible, it is necessary to increase these pre ures by passing their names along to legitimate emplo ment agencies, personnel management firms, a financiers with risk capital.

**The complex legal details of such procedures are described in the first, and only, issue of the Nocturnal Legal Review.*

In a few stubborn cases, one finds progressive company ianagements that reward key personnel with stock opons as well as a good salary. By this means, the actual ionetary reward to the key personnel can be considerble, since the profits obtained when the options are xercised are only subject to the long-term capital gains ax. Of course, such options dilute the stockholder's quity and are only valuable if the stock price rises, but iost progressive companies can show that such options re a highly effective incentive that, in most cases, actualy leads to an increase in equity and share value. Under hese conditions, the key personnel are best spirited away y inducements to start their own companies and acquire n even larger share of stock options.

Having thus disposed of the key personnel, we must ow efficiently fill the rather complete vacuum they leave ehind. We have found that this is best done by replacng them with senior management personnel whose last echnical experience was with a 6SN7 cathode-follower nd who are presently participating in "on-the-job reirement." Such stable, dependable, employees will njoy their new responsibilities and, in attempting to ischarge them in accordance with established company rocedures, they can be counted on to be complete failres. However, we must also discourage the few ambiious junior engineers from carrying on the successful peration. Here, the counterpart of Gresham's law in conomics is quite effective.

First, it is necessary to induce the new managenent to hire more people for the expansion that will urely take place under their fresh guidance. Since they vill hire people at their own level of competence (or ower usually since they greatly fear any competition), he staff will soon be overflowing with mediocrity. Then, f the necessary paper work is increased to improve efficincy, it is found that the few ambitious junior engineers vill simultaneously languish in the new atmosphere and ither leave or decay along with the rest of the group.

Having thus disposed of the major threats to our ruintion scheme and having firmly established the growing ucleus of mediocrity that leads to decay, it is only ecessary to institute a few more proper personnel poliies. The most effective of these is to bring to the ompany "fresh new talent" from some other operation hat is widely known to be a resounding failure. These eople must be placed on the highest executive level with great fanfare in the form of announcements indicating ow well things will now go because of the company's ood luck in being able to attract such competent people. After a short time these people will exhibit their characeristic traits—instinctive fear of any action, disdain for ll underlings, etc.—which when coupled with rumors f their enormous salaries can be counted on to spread ood will and inspiration among all employees.

We have uncovered an unusually large number of hese destructive personnel measures and will be glad to iscuss them further for our usual fee. However, just he few described above will work wonders in almost very case and in almost all industries, but they must be oupled with proper contractual procedures to produce successful failure.

B. By Proper Contractual Procedures

The obvious contractual procedures such as late delivery, overruns, etc. are ineffective for our present purpose because they only guarantee financial loss (through cancellation of existent contracts or by creating difficulty in obtaining new ones) without the desired increase in sales volume. There is, however, a very effective procedure that leads not only to the desired goals but also to a temporary increase in technical prestige—being the low bidder on all exotic, new development programs.

Carrying out this procedure successfully is not as simple as it might appear, however, because many legitimate companies often try it to enable them to break into new fields where large profits can be expected in the future. We have found that by hiring professors on sabbatical leaves to write the necessary technical proposals and then glamorizing these proposals with glossy adjectives, art work, nearly true claims of past performance, and biographies of the world's leading scientists, the technical competition can be eliminated or at least held to a draw. Then, it is only necessary to offer to do the job on a cost-sharing basis at a ridiculously low proposed rate of expenditure to completely capture any desired development program.

To fully exploit this auspicious beginning, however, proper training becomes of the utmost importance since the backlog diminishes steadily as the financial losses rise with the passage of time. In most cases, we have found that in the early stages when the backlog is still quite high, it is not difficult to convince a competent management in another company that is is reasonable to expect a large financial loss in the near future.

III. CONCLUSIONS

We have indicated some effective procedures for turning an established electronics company into a successful failure, that is a company that has an increasing sales volume as well as large financial loss. Once this has been accomplished, it is an established fact that the company so rearranged can be sold on a very profitable basis. Although the managements of some legitimate companies may be forewarned about our procedures by reading this article and use antidotes to counteract them, we are not greatly concerned because of the strong tendency toward "on-the-job retirement" we have noted in most management personnel.

PROF. DR. Z. X. GADFLY was born. Subsequently, he received his technical training at the Hochschule von Hardnoks. He graduated upon payment of tuition and received an advanced degree in Phleminstralungverstarker Physics with a minor in penmanship. After publishing 3741 technical papers and receiving 902 patents, his psychiatrist convinced him that introverts were really extroverts that were overcompensating, and he consequently gave up his scientific pursuits. Simultaneously, the company that employed him was forced into bankruptcy while exploiting Dr. Gadfly's best ideas. Dr. Gadfly then reorganized the company under the name of the Upmanship Institute, where he receives considerable remuneration in the form of a tax loss for running a technical management advisory service, a job for which his penmanship training makes him well qualified.

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Stoddart attenuators* provide highly accurate and stable operation over the frequency range of dc thru 3000 mc and are available in any value, including fractional values, from 0 db thru 60 db in any conceivable combination of Types N and C connectors, and a wide variety with flanges for panel mounting. 50-ohm terminations, dc thru 7000 mc, and 70-ohm terminations, dc thru 3000 mc are also available.

Stoddart's new turret attenuators*, 2, 6 and 10-position, offer quick change of db combinations compatible to your system requirements.

**Patent applied for*

Send for 16-page catalog No. AT-3

SEE OUR SPECIFICATIONS IN
VSMF
THE MICROFILM CATALOG FILE

STODDART
AIRCRAFT RADIO CO., INC.
6644 Santa Monica Blvd., Hollywood 38, Calif. HO 4-9292
serving 33 countries in radio interference control

New Products

(*Continued from page 115*)

MECA COAXIAL TERMINATION LINE FEATURES RUGGED CONSTRUCTION

Meca Electronics, Inc., Dover, N. J has announced a line of 50 ohm coax terminations. The units feature rugg construction, shock and vibration resi ance, thin film metal to glass attenuati elements, and very low VSWR characte istics.

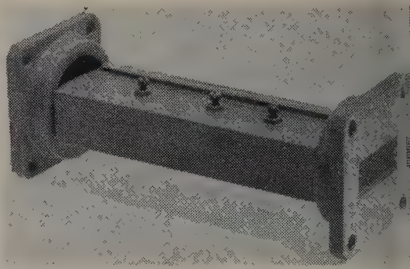
Electrical specifications include a average power rating of 3 watts, frequen range of 0 to 5000 Mc, and a VSWR 1.09 or less at any frequency up to 500 Mc.

The units are available in eight standa connector configurations, including connector types N, C, BNC, TNC male an female. All specifications apply to an type connector.

Circle Reader Service Card 122

— *m w j* —

SCOPE "MODU-FILTER" OPERATES OVER RG-52 WAVEGUIDE RANGE



A new design in microwave bandpa filters, called the Modu-Filter, has been i troduced by Scope Incorporated, Fal Church, Va.

Through modular construction, th Modu-Filter presents a combination custom engineering and off-the-shelf pri and delivery.

Available in both Butterworth an Tchebyscheff designs, Modu-Filters ca be constructed to operate over the RG- waveguide range (8.2-12.4 kMc). U loaded Q's of 2200 per cavity can be rea ized. For example, a Modu-Filter with center frequency of 9010 Mc and a ban width at 3 db points of 20 Mc, has a max mum insertion loss at center frequency 1.2 db.

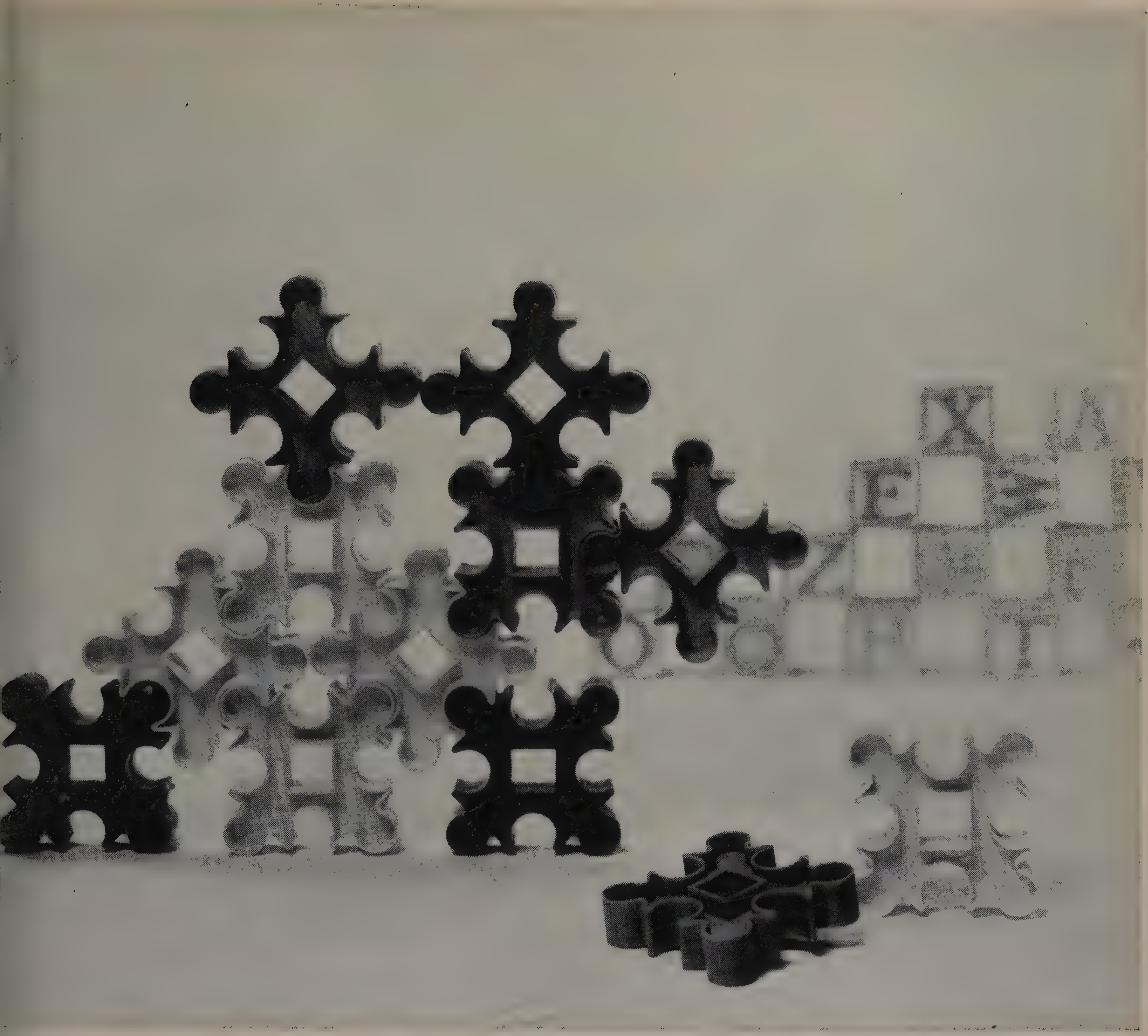
Investment-cast filter segments, designe to be connected at non-critical points ar having irises cast in place, are stocke and ready to be assembled to meet custor er specifications. Modu-Filters for oth waveguide sizes (L through K band) a being added to the inventory.

Circle Reader Service Card 123

— *m w j* —

(*Continued on page 120*)

Circle Reader Service Card 63



SPECIALS FROM STANDARDS

. . . in large waveguide

From standard large waveguide, to special configurations designed to performance specifications, I-T-E offers the industry an engineering and manufacturing background that covers the historical span of modern communication systems.

The wide range of stock waveguide configurations (from WR430 to WR2300) offers easier solutions to special applications by slight modification of existing designs. Yet, in applications where the problem cannot be solved by this simple expedient, I-T-E engineers offer the background and experience to approach your specific problem in large waveguide and accessory design scientifically.

Quite often, this capability and direct approach saves you time and excessive cost. And the application of known and tested advancements in the art is your assurance that the project will succeed.

For further information on I-T-E standard waveguide write I-T-E Circuit Breaker Company, Special Products Division, Dept. MJ, 601 E. Erie Avenue, Phila. 34, Pa. or call GArfield 6-5700. Ask for the catalog on large waveguide components.

I-T-E

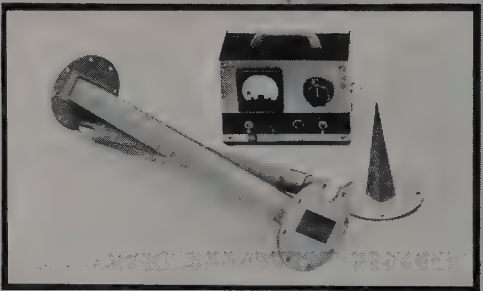
I-T-E CIRCUIT BREAKER COMPANY

SPECIAL PRODUCTS DIVISION

*Noise power at the input of a theoretically perfect receiver where k is 1.374 x 10^{-23} watts per degree Kelvin per cycle, T is the temperature in degrees Kelvin, and Δf is the bandwidth of the receiver.

$$(db) = 10 \log_{10} (kT\Delta f)^{*}$$

RANDOM NOISE GENERATORS
Recognizing this formula for the noise power at the input of a theoretically perfect receiver is important in designing new equipment. Achieving the best possible receiver noise figure requires a reliable standard of noise power for accurate measurements. To provide engineers with these standards, General Microwave has designed two series of random noise generators: Model 501, six waveguide sizes, frequency range from 2.6 to 18.0 Gc, temperature-insensitive, built-in matched termination, constant noise output from 15.2 to 16.0 db, companion Model 301 Universal Power Supply; Model 503, coax, frequency .03 to .5 Gc, built-in power supply, variable noise output 0-19 db. Send for engineering bulletin with specifications.



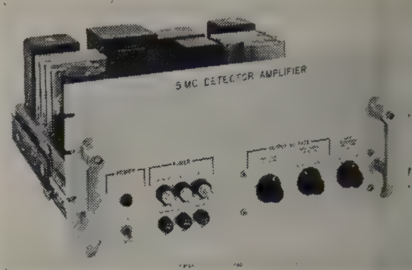
GENERAL MICROWAVE
CORPORATION
47 GAZZA BOULEVARD, FARMINGDALE, NEW YORK
MYRTLE 4-3434

Circle Reader Service Card 65

New Products

(*Continued from page 118*)

DYNATRONICS DESIGNS DETECTOR AMPLIFIER



Dynatronics (Van Nuys, Cal., Orland Fla.) announces a 5 Mc detector amplifie for wide band frequency modulated si nals. The model 5100 is designed for reco ering PCM, PAM, and FM telemetry sig nals which have been hetrodyned to standard 5 Mc IF frequency.

An integral part of the 5100 is a high gain wide-band DC amplifier followin the discriminator which is capable of dri ing a long 75 ohm coaxial line. Deliver is 60 days.

Circle Reader Service Card 124

— *m w j* —

SAMPLE QUANTITIES OF RADAR DISPLAY TUBE PRODUCED

Availability of sample quantities of wideband microwave detector, amplifie and cathode ray display tube combine in one vacuum envelope has been a nounced by the Microwave Device Div sion (Mountain View, Cal.) of Sylvan Electric Products, Inc.

Known as the Wamoscope (wave mod lated oscilloscope), the device was fir developed for national defense applic tions by General Telephone & Electroni Laboratories.

R. A. Stonesifer, product sales manag for the Microwave Device Division, sa that design modifications have resulted a bandwidth of 100 megacycles to 10,0 megacycles, making the tube particular suitable for use in high-resolution rad systems. Since the tube can perform a the functions of a conventional radar ceiver, extreme simplicity and light weig can be achieved in portable equipme The tube operates with no TR device other auxiliary equipment other than beam-focusing system and power supplie Although the present upper frequen limit of the Wamoscope is 10,000 meg cycles, the tube can be modified for ope tion at higher frequencies.

Circle Reader Service Card 125

— *m w j* —

(*Continued on page 122*)

Bendix Craftsmanship at work for you

TWO-67
MADE IN U.S.A.
Bendix

AVAILABLE TYPES
Solenoid Focused

Type TWO-88 with frequency range of 30 Gc to 40 Gc
Type TWO-75 with frequency range of 40 Gc to 50 Gc
Type TWO-67 with frequency range of 49 Gc to 59 Gc
Type TWO-82 with frequency range of 50 Gc to 60 Gc
Type TWO-66 with frequency range of 61 Gc to 71 Gc
Type TWO-83 with frequency range of 65 Gc to 75 Gc
Type TWO-85 with frequency range of 70 Gc to 85 Gc
Type TWO-87 with frequency range of 85 Gc to 100 Gc
Type TWO-90 with frequency range of 100 Gc to 120 Gc
Type TWO-93 with frequency range of 120 Gc to 140 Gc

Available now permanent magnet focused type TWO-89 with frequency range up to 180 Gc

LARGEST LINE OF MILLIMETER WAVE LENGTH BWO Bendix® BWO tubes for higher frequency transmission. These Backward-Wave Oscillator Tubes—exclusive with Bendix—generate microwave energy over the largest continuous frequency range. Ideal for advanced multichannel telephone and television systems, microwave spectroscopy, high definition short range radar, highly directive communications, and many other applications needing low power, voltage-tuned millimeter wave length radio frequency energy. Write today for complete information. Electron Tube Products, The Bendix Corporation, Eatontown, New Jersey.

ELECTRICAL DATA

requency Range	30 Gc-180 Gc (see specific type)
node Voltage	1000-4000 volts
ower Output	Up to 20 mw average (depending on frequency)
eam Current	10 MA
agnetic Field	2000 gauss
eater Voltage	6.3 ±10%

MECHANICAL DATA

Output Flange	Special adapter to RG-98/U (50-75 Gc)
Maximum Diameter	0.625″
Length	8″
Mounting Position	Any
Weight	5 oz.*

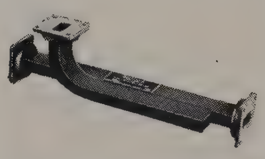
*Without magnet (tube only). Magnets are available.

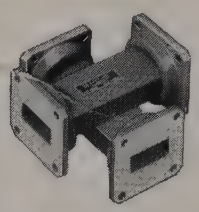
Red Bank Division

THE Bendix CORPORATION

Circle Reader Service Card 66

Waveguide directional couplers





The directional couplers illustrated are representative of the complete line of standard couplers designed and manufactured by Waveline. These precision microwave instruments cover the frequency range of 2.60 to 40.0 KMC in a number of basic design configurations, such as: cross-guide, narrow-wall, and precision broad-wall couplers. All models are available with standard values of coupling and are manufactured of rugged brass construction with silver plating and baked enamel finish.

Your attention is invited to the many special couplers designed and manufactured by Waveline for system applications. These devices have been produced in a variety of complex configurations utilizing Waveline's engineering skills and advanced technique of aluminum flux dip brazing. Our modern facilities are capable of generating basic designs in the form of prototypes for evaluation, as well as, quantity production of established designs.

We welcome your inquiry concerning standard couplers or your special coupler requirements covering design of prototype and manufacture of production quantity.

A six page illustrated brochure of Waveguide Directional Couplers is available on request.

WAVELINE INC.
CALDWELL, NEW JERSEY
Phone: CApital 6-9100 TWX Caldwell, N. J. 703

New Products

(Continued from page 120)

ALFRED CRYSTAL DETECTOR PROVIDES FLAT FREQUENCY RESPONSE

A crystal detector, providing exceptio ally flat frequency response of ±1 db ov the entire 1 to 11 Gc range, has been i troduced by Alfred Electronics, Palo Alt Cal.

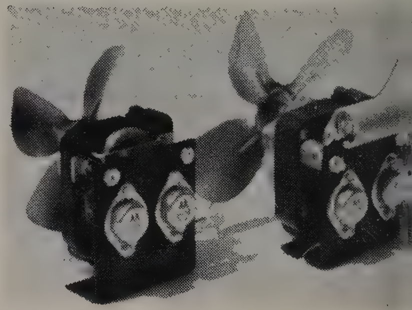
Careful construction of the Model D12 Crystal Detector, which operates fro 1-12.4 Gc, assures VSWR of less than 2. to 1. Sensitivity is .1 volt per milliwat maximum input power is 20 mw.

Use of the Alfred detector permits a curate oscilloscope display of RF compo nent characteristics which vary with fr quency. The flat response of the detecto can also be used for automatic gain c power control.

Circle Reader Service Card 126

— *m w j* —

ROTRONICS CABINET FAN USES NO BRUSHES



Rotronics of California, Los Angel Cal., introduces a low cost commercial u that meets the temperature requireme of Mil-E-5272-C (—65 to 160° F.), brushless and radio noise free.

By eliminating the brushes, commutat and armature windings, a life expectan limited only by the bearings is obtaine Under normal conditions, this increase at least ten times that of conventional D units.

Reliability is greatly increased, especia ly after extended shelf life. The elimin tion of brushes makes operation in corr sive or explosive atmospheres possible.

Although a shade pole motor is use much higher operating efficiencies are o tained than are normally possible shaded pole starting motors. Motor an electronic circuitry was developed by W. Von Brimer.

Circle Reader Service Card 127

— *m w j* —

(Continued on page 124)

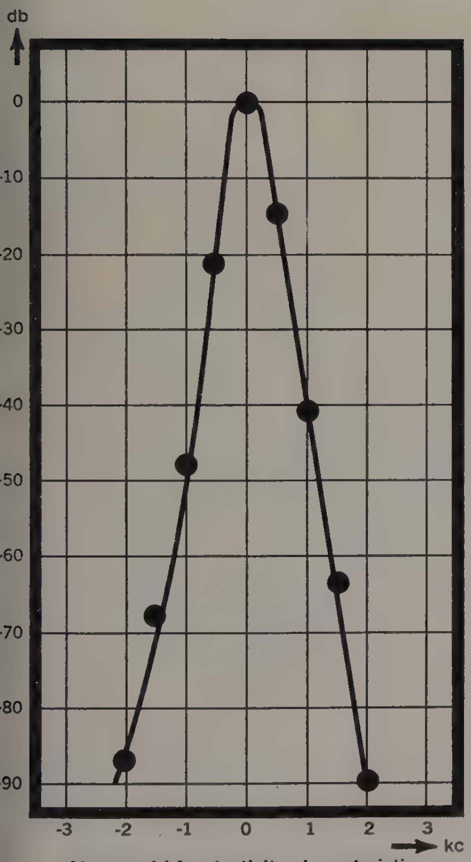
NOTHER **UNIQUE** INSTRUMENT FROM ROHDE & SCHWARZ

10 kc
TO
30 mc

TYPE USVH

elective Microvoltmeter

DELIVERY FROM STOCK



Measured i.f. selectivity characteristic.
Bandwidth 500 cps.

Unique Features

- **Extremely wide frequency range: 10 kc to 30 mc.**
- **Fine frequency adjustment: ±2.5 kc.**
- **Bandwidth, selectable: 500 cps and 5 kc.**
- **Full-scale deflections, 1 μv to 1 v.**
- **Six input impedances from 50 Ω to 500 kΩ available.**

Here is a highly sensitive superheterodyne receiver whose output voltage is indicated by a diode voltmeter. A switch permits selection of any of the conventional input impedances. Single frequency changing is used for input frequencies from 10 to 1000 kc, double frequency changing for 1 to 30 mc, the bandwidth being 5 kc in both cases. Additional frequency conversion takes place in 500-cps narrow-band operation.

The local oscillator can be varied in frequency by ±2.5 kc and thus permit shifting of the 500 cps pass band over the 5 kc bandwidth present up to this frequency conversion.

The meter is calibrated in volts and decibels, and features an additional expanded scale with a relative calibration from 0.7 to 1. A head-phone output provides aural monitoring. A built-in calibration oscillator permits checking and adjustment. The power supply is electronically regulated for greater stability with regard to gain and frequency accuracy.

Typical Measurement Applications

- Frequency response on four-terminal networks, especially at low voltage levels.
- Frequency response on amplifiers or filters within their pass bands.
- R-f distortion of long-, medium- and short-wave transmitters.
- Modulation depth.
- Envelope distortion.
- Inter-channel cross-talk attenuation.
- Signal-generator attenuation.
- R-f leakage on shields and r-f chokes.

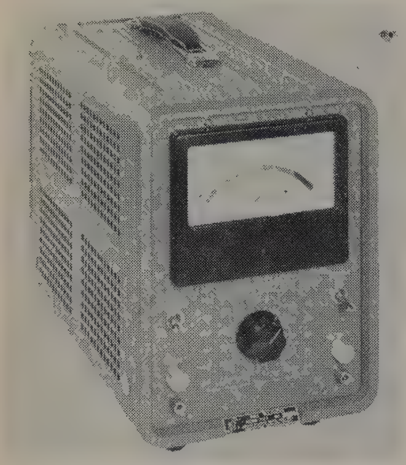
WRITE FOR
ADDITIONAL
INFORMATION

ROHDE & SCHWARZ
ELECTRONIC MEASURING EQUIPMENT FOR THE UNCOMPROMISING
111 Lexington Ave., Passaic, N. J. • PRescott 3-8010

New Products

(*Continued from page 122*)

AMPLIFIER OUTPUT PROVIDED WITH RMS VOLTMETER



The new Fluke model 910A True RMS Voltmeter, provides 1 percent midband accuracy, 10 cps to 7 Mc bandwidth, plus 100 uv maximum sensitivity, for measuring true RMS value of virtually all waveforms. For added versatility an amplifier output has been provided for simultaneous oscilloscope or recorder monitoring.

In addition to high accuracy and broad bandwidth, the Fluke 910A features: High input impedance, high sensitivity, and fast response.

Some of the measurement applications recommended include: noise and microphonics, total harmonic and intermodulation distortion, RMS ripple voltage, audio power; currents and losses in transformers, coils, ferrite cores, magnetic amplifiers, capacitors, diodes, and other nonlinear devices.

Circle Reader Service Card 128

— *mwj* —

PORTABLE NANOVOLTMETER FEATURES 13 FULL SCALE DC RANGES

An all-transistorized nanovoltmeter, featuring 13 full scale dc ranges of ±0.1 microvolt to ±100 millivolts, has been introduced by Astrodata, Inc., Anaheim, Cal.

Completely portable, the nanovoltmeter weighs just 16 pounds and dissipates only 0.6 watts of power. It uses a built-in battery supply, allowing fully floating (differential) operation free from the effects of 60-cycle interference. The instrument also features a built-in battery charger.

Input resistance of the nanovoltmeter is 1 megohm on all ranges; source resistance may vary from 0 to 2000 ohms. The zero center mirror-backed meter scale provides 2 per cent accuracy. Amplifier output (recorder) terminals supply 0 to ±5 volts full-scale at 10 milliamperes from dc to 100 cps. Drift is only 0.05 microvolts per hour, 0.15 microvolts per day, or 1 microvolt per six months. The amplifier gain is adjustable from 30 to 1 million and accurate to 1 per cent.

Applications include amplification seismograph signals, bridge balance nu indicator, measurement of electrochemic potentials, cell and Hall-effect studie bolometer indicator and ultra low-lev thermocouple and strain-gauge work.

Circle Reader Service Card 129

— *mwj* —

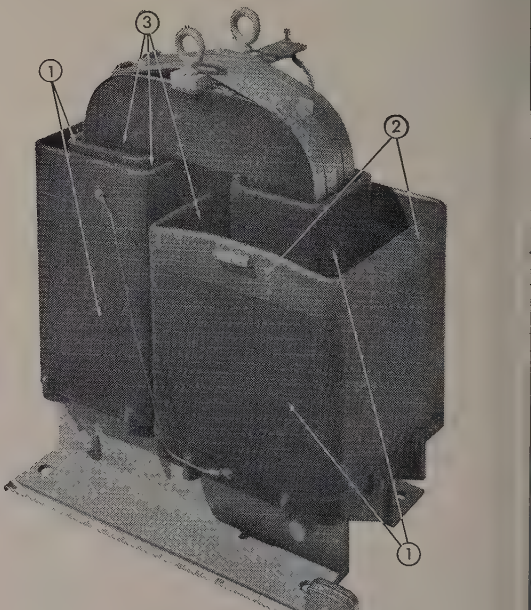
(*Continued on page 126*)

EPIC

EPOXY INTEGRALLY CAST

High Voltage Pulse Transformers

- Higher performance capability in a given space
- Air-free windings
- Higher voltages with greater reliability
- For radar applications, linear accelerators, tube testing, pulse X-rays, pulse neutron generators



Check the range of basic types below; write for additional information and detailed specifications.

	Voltage Ratings	Impedance Levels	Pulse Widths
Magnetron Types	5 to 40 KV	300 to 1500 ohms	.2 to 8 μsec.
Amplitron Types	40 to 150 KV	120 to 1200 ohms	1 to 10 μsec.
Klystron & TWT Types	90 to 500 KV	900 to 3000 ohms	1 to 40 μsec.
High Impedance Types	150 to 500 KV	5K to 50K ohms	5 to 50 μsec.

1. *Windings vacuum cast in Epoxy shells*
2. *Voltage grading shield at HV output*
3. *Interwinding spaces for oil convection*

CARAD CORPORATIO
HIGH ENERGY ENGINEERIN
Stanford Industrial Park • Palo Alto, Califor

Circle Reader Service Card 69

Max. MegW/cu. in.

KU94
Kuthe Laboratories Inc
KU 274
Kuthe Laboratories Inc
KU74
Kuthe Laboratories Inc
KU93
KU73
KU72
KU70
KU92
KU71

ITT CERAMIC HYDROGEN THYRATRONS AND DIODES FOR MAXIMUM POWER/SIZE RATIO

No other hydrogen thyratron and diode line offers this wide choice of high-power types in the smallest possible tube envelopes. Made by ITT Kuthe Laboratories, most experienced maker of hydrogen-filled tubes, these ceramic thyratrons and diodes are the most complete line on the market today, with each type immediately available from production. The high-power thyratrons are designed to operate at high repetition rates and high temperatures; the high-power diodes may be used as hold-off diodes, inverse clippers and backswing clippers. Also available is an equally comprehensive line of glass thyratrons. The entire ITT hydrogen thyratron and diode program is aimed at the most demanding applications, particularly where long life and ruggedness are mandatory.

THYRATRONS	KU 70	KU 71	KU 72	KU 73	KU 74	KU 274
Performance Factor (x 10^9)	1.0	4.0	7.0	20.0	40.0	45.0
Peak Power Output, Megawatts	0.2	1.0	3.50	12.50	33.0	50.0
Forward Anode Voltage, Kilovolts	6.0	10.0	20.0	25.0	33.0	50.0
Peak Anode Current, Amperes	90	200	350	1000	2000	2000
Average Anode Current, Amperes	.100	.200	.300	1.5	4.0	4.0
Height, Inches	1.70	2.25	3.00	5.75	11.0	12.0
Diameter, Inches	1.15	1.37	1.75	3.00	4.50	4.50

DIODES	KU 92	KU 93	KU 94
Peak Inverse Voltage, Clipper, Kilovolts	25.0	33.0	33.0
Peak Forward Current, Clipper, Amperes	300	500	2000
Max. Average Current, Clipper, Amperes	.200	.500	2.0
Peak Inverse Voltage, Rectifier, Kilovolts	15.0	20.0	20.0
Peak Forward Current, Rectifier, Amperes	2.0	8.0	16.0
Max. Average Current, Rectifier, Amperes	.50	2.0	4.0
Height, Inches	3.00	6.00	8.25
Diameter, Inches	1.75	3.00	4.50

Write for information on the complete line of ITT hydrogen thyratrons and diodes. Application assistance is available for your specific requirements.

ITT

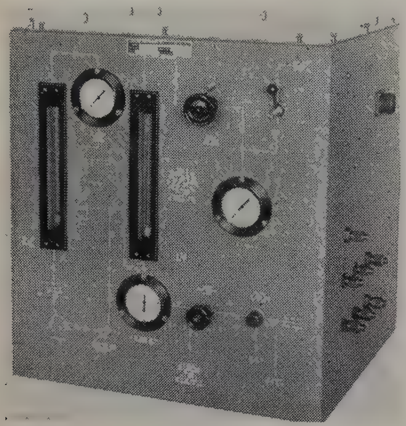
ELECTRON TUBE DEPARTMENT ■ COMPONENTS DIVISION
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, CLIFTON, NEW JERSEY

ITT COMPONENTS DIVISION PRODUCTS: POWER TUBES • IATRON STORAGE TUBES • HYDROGEN THYRATRONS
TRAVELING WAVE TUBES • SELENIUM RECTIFIERS • SILICON DIODES AND RECTIFIERS • TANTALUM CAPACITORS

New Products

(*Continued from page 124*)

GAS PURIFYING AND PRESSURIZING SYSTEM USED WITH WAVEGUIDES



A new system for purifying and pressurizing gas for use with waveguides, cavities, duplexers, co-axial cable, and TV transmission lines has been announced by Applied Pneumatics, Inc., Kenilworth, N. J.

The unit utilizes Sulphur Hexafluoride (SF_6), a stable, non-toxic, gaseous dielectric, however, is easily convertible for use with air or other gases. All breakdown products, air, and water are removed leaving only SF_6 or other primary gas with no impurities to form breakdown products. Extremely low dewpoint is maintained.

With SF_6, heat transfer is substantially higher, without conducting carbon deposits. The system has 2½ times the dielectric strength of air or nitrogen, and arc quenching ability 100 times that of air pressurization systems. Operation is completely automatic. Corona and arcing points are suppressed. High dielectric strength allows operation at high power levels. 25,000 hours minimum life. Recirculation capacities from 1/10 to 5 SCFM. Meets MIL specs.

Circle Reader Service Card 130

— *m w j* —

MI-CO ANNOUNCES COAXIAL COMPLETELY VARIABLE ATTENUATOR

Mi-Co Products Co., Ontario, Cal., has announced a coaxial, completely variable attenuator. The "Copot" RF attenuator was developed for use in confined spaces where size is a limiting factor.

With an insertion loss of less than 0.5 db, and a VSWR of 1.5 max., for all values of attenuation, the unit is capable of handling 2 watts average power or 2 kw peak power.

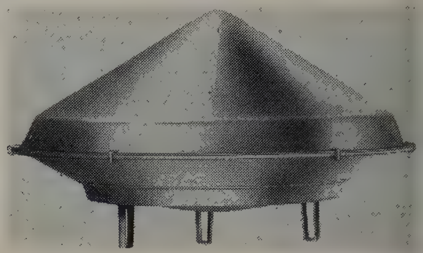
The "Copot" attenuator is available with either type N male or female connectors. It is readily adaptable to servo drive and will withstand temperatures to a maximum of 200 degrees F for long periods, or 300 degrees for short periods.

Circle Reader Service Card 131

— *m w j* —

LOW-LOSS TACO RADOME PROTECTS ANTENNA UNDER ADVERSE CLIMATIC CONDITIONS

Snow, ice, accumulated leaves and sand may seriously affect the performance of any microwave antenna, and for this reason Taco, Sherburne, N. Y., engineers have developed a low-loss radome that offers complete protection under the most adverse climatic conditions.



Specifically designed to shed extraneous material, Taco radomes keep the antenna aperture clear for effective RF transmission.

Available for all standard size reflectors the radomes can be supplied for heated, unheated, linear or dual polarized antenna designs. Heated radomes are complete with thermostatic control.

Anti-icing may also be accomplished by the use of reflector and feed heaters. Feed heaters are designed for use with standard taper or button hook feeds.

Circle Reader Service Card 132

— *m w j* —

(*Continued on page 128*)

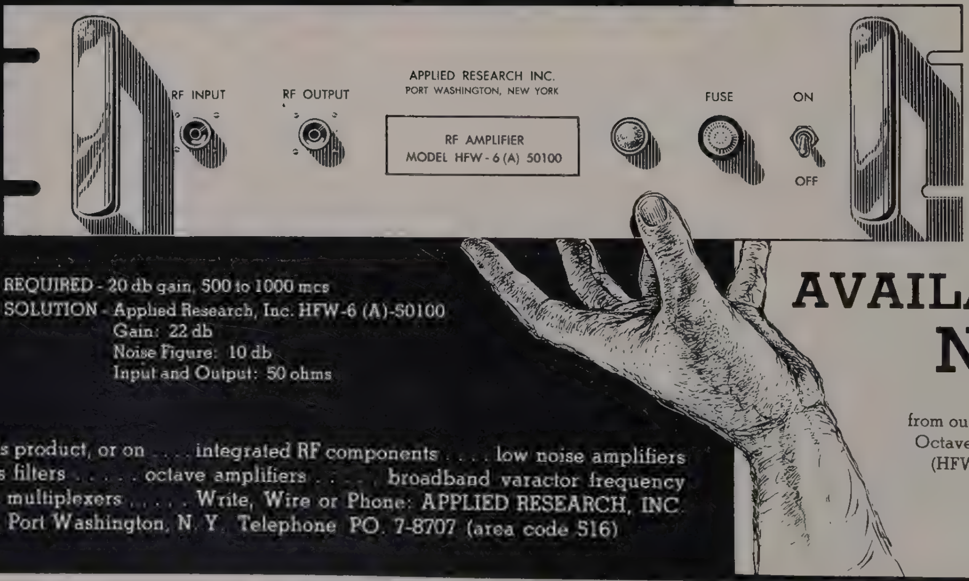
500 TO 1000 MC

BROADBAND AMPLIFIER

Applied Research inc.
76 South Bayles Avenue, Port Washington, N. Y.

VERSATILE Design

(gain per stage) x (number of stages) = gain



EXAMPLE
REQUIRED - 20 db gain, 500 to 1000 mcs
SOLUTION - Applied Research, Inc. HFW-6 (A)-50100
Gain: 22 db
Noise Figure: 10 db
Input and Output: 50 ohms

AVAILABLE NOW

from our expanded Octave Amplifier (HFW) Series

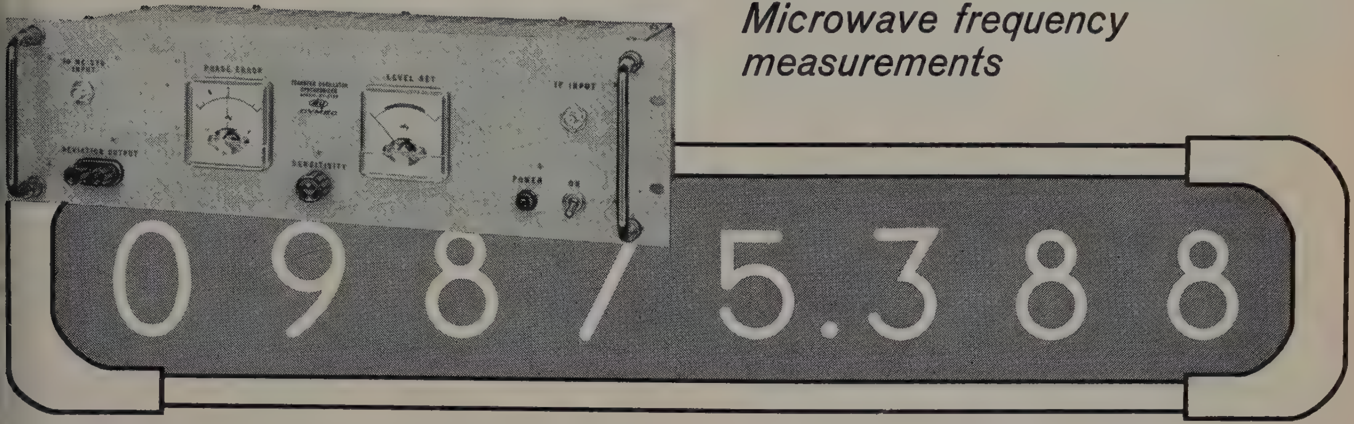
FOR DATA on this product, or on .... integrated RF components .... low noise amplifiers ..... band pass filters ..... octave amplifiers ..... broadband varactor frequency multipliers ..... multiplexers ..... Write, Wire or Phone: APPLIED RESEARCH, INC. 76 S. Bayles Ave. Port Washington, N. Y. Telephone PO. 7-8707 (area code 516)

Circle Reader Service Card 71

MEASURE FREQUENCY, 200 MC to 12.4 GC,

with COUNTER ACCURACY!

Faster
More accurate
More useful
Microwave frequency measurements



Introduce counter accuracy to your microwave frequency measurements with the unique Dymec Transfer Oscillator Synchronizer! Model DY-5796, used with a Hewlett-Packard Transfer Oscillator and an hp Counter, permits high-accuracy automatic frequency measurements, even on varying signals, all the way to 12.4 GC.

With the hp 540A/B Transfer Oscillator and hp 524/525B Frequency Counter, the DY-5796 Synchronizer provides positive locking of the transfer oscillator to the signal frequency . . . thus giving you measurement accuracy equal to that of the counter time base. Higher accuracies can be achieved with an external frequency standard, such as the hp Model 103A Quartz Oscillator, which provides short term stability better than 5 parts in 10^{10}. The hp 524C and 525B Frequency Converter covers 100 to 220 MC, and the hp 540A (with external hp 934A Harmonic Mixer) or 540B (with the mixer built in) extends your measuring range to 12.4 GC.

By keeping the transfer oscillator and the signal frequency in permanent synchronization, the DY-5796 also permits long term measurements of low drift rates at microwave frequencies. FM deviations up to 0.2% of the carrier frequency can be measured with the addition of a VTVM and/or oscilloscope. Further, this instrument and the associated equipment greatly simplify determination of the harmonic number and microwave frequency.

The DY-5796 Synchronizer is available from Dymec for use with your present hp Transfer Oscillator* and Counter—or you can use the Dymec 5854 Frequency Measuring System composed of the Synchronizer and the optimum related hp equipment mounted in only 52½″ of rack space.

SPECIFICATIONS

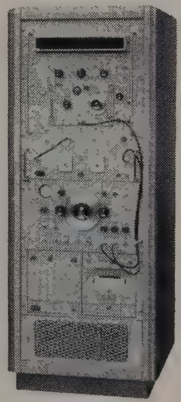
DY-5796 Transfer Oscillator Synchronizer

Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum*
Price:	$685.00

*With Modification Kit 9200-0028 for 540A/B Oscillator. $65.00

DY-5854 Frequency Measuring System

Includes synchronizer, modified transfer oscillator, electronic counter with frequency converter, digital recorder with analog output, cabinet and interconnecting cables.



Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum
Accuracy:	± 1 count ± stability
Stability:	$3/10^8$ short term, $5/10^8$ per week with 524C/D internal time base. May be used with external frequency standard, e.g., hp 103AR, for greater accuracy.
Registration:	9 places: first 2 on converter dial, next 7 on counter.
Printout:	Full readout of counter printed on paper tape.
Analog Output:	For Potentiometer Recorder: 0-100 mv. Minimum load resistance 0.5M. Calibrate control. For Galvanometer Recorder: 0-1 ma into 5000 ohms or less. Zero and calibrate controls.
FM Measurement:	Deviations up to 0.2% of signal frequency at rates to 1 kc. Above 1 kc, max. deviation limit reduced at 20 db/decade to max. of 0.001% at 200 kc.
Price:	$6,405.00.

Data subject to change without notice. Prices f.o.b. factory.

Write to your Dymec/Hewlett-Packard representative or contact us directly for complete information.

DYMEC
A division of HEWLETT-PACKARD COMPANY

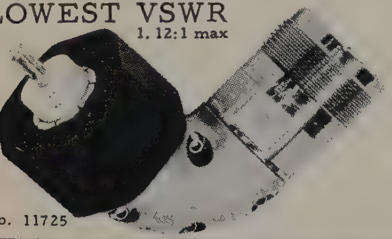
dy

DEPT. J-11, 395 PAGE MILL ROAD, PALO ALTO, CALIFORNIA • DAvenport 6-1755 • Area Code 415 TWX-117-U

7204

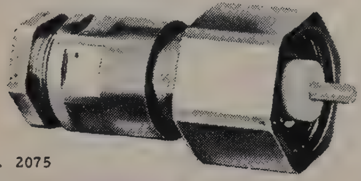
HOW
TO SOLVE
MICROWAVE
PROBLEMS

Adapter 90°, LT Series, Male to Female
LOWEST VSWR
1. 12:1 max



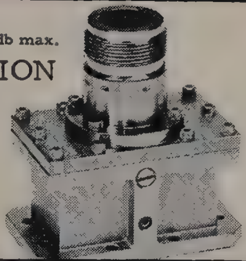
No. 11725

Connector, LT Series, Male
HIGH POWER
500 watts CW at 5000 mcs



No. 2075

Adapter,
LOW 0.25 db max.
INSERTION
LOSS
Waveguide
to Coax,
WR 229 to
LT Series,
Female



No. 2600

Scimitar Antenna
BROAD
BAND
P-Band

No. 3400

TAMAR
solves many RF problems with off-shelf items, or components and systems custom designed.

High Power Testing
...Write for test facilities brochure and component literature.

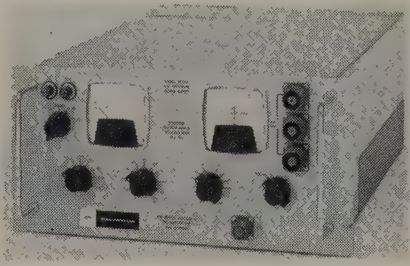
TAMAR
ELECTRONICS, INC.
GARDENA, CALIFORNIA
TWX CPT 6089

Circle Reader Service Card 73

New Products

(Continued from page 126)

CARAD POWER SUPPLY FEATURES PRECISION DIAL-SET VOLTAGE



A high-stability, low-ripple power supply, now in production by Carad Corp., Palo Alto, Cal., offers precision decade output dialing from 500 through 5060 volts with ultra-flat regulation.

Though designed primarily for photomultiplier and ionization chamber applications, the power supply's unusual stability and flexibility make it suitable for test, laboratory, and general production utilization, wherever a precision voltage source is required.

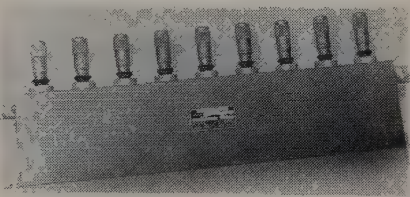
Output voltage regulation is constant within 0.001 per cent, even with variations as high as 10 volts in the 115 volt input. Load regulation, for no-load to full-load output current of 10 ma, at any output voltage level, is 20 millivolts + 0.001 per cent. Stability, after nominal warm-up, is 0.005 per cent per hour. Maximum rms ripple is 1 millivolt.

Output voltage is selected by 3 dials; the first in 500 volt increments, the second in 50 volt increments, and the third continuously from 0 through 60 volts. Polarity of output is reversible by a front-panel switch. Output voltage and current are displayed on calibrated meters.

Circle Reader Service Card 133

— *m w j* —

BANDPASS FILTER FEATURES STEEP SKIRT SELECTIVITY



A nine-section tunable bandpass filter featuring steep skirt selectivity has been developed by Frequency Engineering Laboratories, Asbury Park, N. J., for laboratory use in selecting desired microwave frequencies.

Tunable over a frequency range of 2200-2300 Mc, the filter has a rejection bandwidth of 40 and 86 Mc at 3 db and 50 db respectively. Insertion loss of the unit is 1.0 db maximum and input VSWR with matched load is 1.3:1.

The filter is multiple-tuned with individual micrometer heads for each cavity. Type N connectors are used for both input and output connections.

Circle Reader Service Card 134

— *m w j* —

(Continued on page 130)

FROM STOCK
BROADBAND DISC
BOLOMETERS

FOR PRD TYPE 627A AND
NARDA TYPE 561 MOUNTS

5-PACK
only $99.00

(Package of 5 BOLOMETERS—4.5 or 8.75 ma)
SINGLE BOLOMETERS $25.00

Features
- Gold electrodes for maximum stability
- Matched 100—ohm Wollaston wire elements
- All units checked for power sensitivity and thoroughly stabilized.
- Low VSWR over 500 mc to 10,000 mc frequency range
- 4.5 ma bias current—SPECIFY FILMOHM TYPE MWB-450
- 8.75 ma bias current—SPECIFY FILMOHM TYPE MWB-875
- BOTH TYPES AVAILABLE FROM STOCK—IMMEDIATE DELIVERY

Ideally suited for attenuation measurement and all relative and absolute microwave power measurements, Filmohm Type MWB Bolometers are provided with alignment holes to facilitate proper assembly in standard suitable mounts. All Filmohm Type MWB Bolometers are precisely constructed to provide element resistance for optimum VSWR and efficiency. In addition, each Bolometer is precision-checked for power sensitivity, thoroughly stabilized for maximum power, and checked to ensure low VSWR over the entire 500 mc. to 10,000 mc. frequency range.

For more information, write or call today.

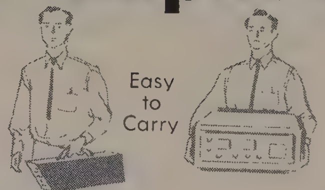
FILMOHM
CORPORATION
48 West 25th St., N.Y. 10, N.Y., WA 4-6605

Circle Reader Service Card 74

Model 714

MPE introduces this truly portable Traveling Wave Tube Amplifier

*A fraction of the space**
*A fraction of the weight***



Menlo Park Engineering presents a completely new package for traveling wave tubes. Light in weight, small in size, this package has been designed for use with low and medium power and low noise traveling wave tubes.

The average weight of these new amplifiers is 12 pounds, about ¼ the weight of the smallest previous package. Along with this we have reduced the size to less than seven percent of the size of previous units with no decrease in the electronic characteristics of the unit. Low and medium noise amplifiers to increase the sensitivity of broadband low level systems are being manufactured in this package with noise figures as low as 7 DB in the standard units. Over selected frequency range noise figures of lower value are available on special order. Low power amplifiers in all bands up to eighteen kmc are being offered with small signal gains of 30 db at approximately 10 mw power output. Medium and high powered tubes having power outputs from 1 to 10 watts will also be offered in this new package.

This new package has been made possible by the use of ppm type focused traveling wave tubes which have a low power consumption and are very light weight. Modern miniature circuit components make this the smallest and lightest unit Menlo Park Engineering has produced to this date.

***occupies only 7% of the volume of previous models**
****weighs only ¼ as much as previous models**

Represented throughout the United States and Canada

MENLO PARK ENGINEERING
711 HAMILTON AVENUE MENLO PARK, CALIFORNIA DAvenport 6-9080 TWX PAL AL-110

For the answers to problems in the design, fabrication, and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy and special antenna products . . .

ASK ASI

A S I

FOR FULL INFORMATION WRITE: ANTENNA SYSTEMS INC.
HINGHAM, MASSACHUSETTS

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SHARP CUTOFF and HIGH REJECTION

Sharp cutoff and high rejection in the Stop Band assured by multi-section design. High dielectric materials and unique construction provide minimum pass band VSWR and insertion loss and minimum size.

RLC ELECTRONICS INC.

RLC F-30 LOW PASS FILTERS

Pass Band VSWR: 1.3 max.
Pass Band insertion loss: 0.2 db max.
Stop Band Rejection (1.35 to 5.0 fc) 60 db min.
Power: 100 watts
Impedance: 50 ohms
Connectors: N, C, TNC

Model F-30 Standard Units

CUTOFF FREQUENCY (Mcs)	LENGTH (Inches)	CUTOFF FREQUENCY (Mcs)	LENGTH (Inches)
100	12 1/4	2000	6 1/2
200	12 1/4	3000	5 7/8
300	12 1/4	4000	5 1/4
400	12 1/4	6000	4 3/4
600	11 1/4	8000	4 3/4
800	9 1/8	10000	4 3/4
1000	7 1/8		

Special filters for other frequencies can be supplied. Write for data.

RLC

R L C ELECTRONICS, INC.
805 MAMARONECK AVENUE • MAMARONECK, NEW YORK • OWens 8-7440

Circle Reader Service Card 76

(*Continued from page 128*)

COAXIAL DUPLEXER USED IN MICROWAVE APPLICATIONS AT L-BAND

A compact, all-solid-state coaxial duplexer for use in microwave application at L-band has been introduced by Microwave Associates, Inc., Burlington, Mass

Designed to provide light weight wi all-solid-state reliability and ruggedness the MA-3477 duplexer is for application which require 5 to 10 per cent bandwid in the 1000-1400 Mc region. It feature long life, low insertion loss (1.0 db maximum), and instantaneous recovery tim (less than 10 millimicroseconds).

Transmitter-receiver isolation at rate power regardless of antenna mismatch i 40 db (minimum). The MA-3477 handle 1.5 kw peak power (at a 0.001 duty cycle and up to 60 watts CW.

The unit offers guaranteed receiver protection independent of antenna mismatch and over-specified temperature operating range. It eliminates the need for all external power supplies and related circuitr since it is a completely passive device.

Input VSWR at any arm, high and low level, is 1.3 (maximum). The temperatur operating range is —55°C to +85°C The MA-3477 meets all military shock an vibration requirements.

Circle Reader Service Card 135

— *m w j* —

MICROWAVE BANDPASS FILTERS NOW MANUFACTURED IN QUANTITY

Microwave bandpass filters, featurin solid cast construction with closely hel mechanical and electrical tolerances, ar now being manufactured in quantity b the Electronics and Microwave Div., Instrument Systems Corp., College Point N. Y.

Used in service and laboratory equipment for frequency analysis, measurement signal separation, and all application where rugged and stable microwave filter are required, ISC microwave bandpass filters are qualified under applicable government specifications for military environments.

The filters are supplied to any designated center frequency between 2000 an 4000 Mc., with a bandpass width of fror 40 to 80 Mc., as required. Low insertio loss and low ripple content, together wit excellent temperature compensation assure maximum performance from the 4 section, tuned element device.

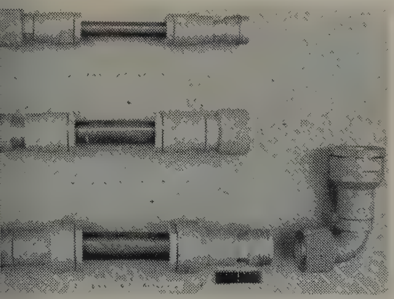
The 10 oz. filter is housed in a hig silicon, silver plated brass casting. Cove and components are soldered in place The price for microwave bandpass filter in single units is $125 with a choice o BNC, TNC, push-on, or N type connectors, male or female.

Circle Reader Service Card 136

— *m w j* —

TRW DEVELOPS SERIES OF MICROWAVE COAXIAL CONNECTORS

A series of high power, high voltage, v VSWR RF coaxial connectors for use h large size cables has been developed the TRW Components Company of ompson Ramo Wooldridge Inc., Los geles, Cal., under contract with the ited States Army Signal Research and velopment Laboratory (USASRDL).



The connector series, designated QM for e with RG-217/U cable and QL for use th RG-218, 219, 220, and 221/U, are replace in new equipments LC, LT, N, C, and N connectors which have en used in the past with those cables. QL and QM connectors are designed for quencies up to 5000Mc, and for power vels compatible with present cable per- rmance specifications. The connectors ve a maximum VSWR of 1.27 to 1 and ature corona extinction values from 6000 lts, 60 cycles rms for the QM series to ,500 volts rms for the QL series.

A cable clamp design, which maintains e cable dielectric in fixed position, contributes significantly to the excellent high voltage and RF characteristics, and is proven by the ability of the connectors to withstand shock, vibration, 200 lb. cable pull, and durability tests with no degradation of VSWR, corona, and leakage performance.

Circle Reader Service Card 137

— *m w j* —

DIRECT READING ATTENUATOR PROVIDES HIGH ACCURACY AT P-BAND

Calibrated to an accuracy of ±2 per cent, over a 12 per cent bandwidth, at calibration frequency, a compact direct reading attenuator from Microwave Components and Systems Corp., Monrovia, Cal., provides up to 10 db of attenuation, despite temperature and humidity changes.

Input VSWR is 1.15 max., with an insertion loss of less than 0.3 db over the frequency range 12.4-18.0 Gc. Having an overall length of 3½ inches, this unit is extremely valuable in system or laboratory applications.

A friction-free, anti-backlash drive mechanism provides accurate determination of attenuation in 0.1 db steps. The 3½ inch section of RG 91/U waveguide is terminated at both ends in standard UG 419/U cover flanges.

A cylindrical housing, containing a "sealed in" viewing window, encases the entire drive mechanism, insuring dust and moisture-free operation.

Circle Reader Service Card 138

— *m w j* —

(*Continued on page 137*)

WAVEGUIDE
SPECIALISTS
IN CLOSE
TOLERANCE
BENDING
AND
FORMING

INTASPACE CORP.
135 ORANGE ST., BLOOMFIELD, N. J.
PIlgrim 8-4700

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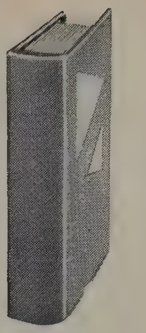


Solve everyday problems in antenna engineering

Here's a handbook of design information to help you solve everyday problems in the design and use of antenna systems. From basic fundamentals to modern design applications, this big handbook offers you the kind of detailed treatment you need for successfully working in today's complex field of antenna engineering. Important data on many types of commercial antenna are included. In addition, a number of developments in the field of military applications are comprehensively treated to make this the most complete and useful source of antenna information available today.

ANTENNA ENGINEERING HANDBOOK

Editor-in-Chief, HENRY JASIK
Jasik Laboratories

1013 pages, 6 x 9, 993 illustrations and charts, $22.00

This practical volume provides a wealth of essential principles, methods, and data to help you solve all kinds of antenna problems, from designing an antenna for radiating energy in an omnidirectional pattern — to determining the lowest theoretically obtainable standing-wave ratio over a required bandwidth. The book details virtually every type of antenna. Further, it treats a wide range of areas of applications. All essential antenna system fields are fully explored. It discusses the problems of operating various systems — from low to ultra high frequencies with their special design considerations. You'll get detailed applications of the basic antenna types to a wide range of fields. In addition, you'll find a wealth of information on how to design antennas to meet particular requirements, such as techniques of impedance matching, solutions to electrical and mechanical problems in the housing of antennas. The book also includes such diverse topics as transmission lines, waveguides, radomes, absorbers, and much more.

For your copy of "Antenna Engineering Handbook" send check or money order to "the microwave journal" — Book Dept. 1330 Beacon St., Brookline 46, Mass.

Enclosed — Check ☐ Money Order ☐

Name ______

Address ______

City ______ Zone ______

State ______

COMPANY PROFILE

SPERRY MICROWAVE ELECTRONICS COMPANY

Clearwater, Florida

(Top photo) — engineering management. (Left to right) R. E. Lazarchik, antennas and radiometers; L. Rehberg, microwave produc G. R. Barton, system performance monitors; J. O. Lalli, engineering planning; P C. Ely, Microline engineering; F. D. Mirabel test instrumentation; P. Henry, automatic checkout equipment; J. E. Pippin, research; Dr. R. E. Henning, chief engineer; Aucremann, automatic checkout equipment; B. J. Duncan and G. J. Neumann, microwave and solid state devices. (Lower le — company management. (Left to right) G. W. Jaynes, Controller; Dr. R. E. Henning, chief engineer; P. J. Andresakis, ind trial relations manager; John H. Leutwiler, division manager; G. M. Scheblein, quality control manager; John G. Sager, spec projects manager; Frank J. Lavelle, marketing manager; E. J. Friebele, manufacturing manager.

Sperry Microwave Electronics Company is an autonomous operating Division of the Sperry Rand Corporation. Within the framework of its Charter, its activities are completely independent of those of other Corporate Divisions. However, as a member of the vast Sperry Rand family, Sperry Microwave can take advantage of the capabilities and specialized facilities of other divisions. This arrangement offers technical and management personnel wide latitude in the selection, performance, and management of all programs.

Sperry Microwave occupies a modern two-story building on 80 acres of tropical greenery just outside Tampa, Florida. Apparently, locating the plant in a so-called 'tourist paradise' was a good idea. Since its inception in 1957, Sperry Microwave has been able to attract and retain high calibre technical personnel; this can't all be attributed to the location. Interesting, varied, and stimulating work along with liberal employee benefit plans play a big part in making Sperry a 'good place to work'. Employing about 1000 people, Sperry's programs range from basic and applied research through large scale production for industry and the Armed Forces. Curre products include: microwave solid state devices ar materials, microwave components, microwave radiometr systems, ground spectral measurement equipment, manu and automatic checkout equipment, custom built suppo equipment and modules, antennas, and Microline* te and measuring equipment for laboratory and producti line use.

Management of Sperry Microwave is in the hands of Division Manager and his Staff. The lion's share of th credit for organizing and getting Sperry Microwave u der way must go to E. J. Venaglia, Division Manag until May 1961. At that time, Mr. Venaglia was selecte by the Sperry Rand Corporation to transfer his skill the management of its multi-million dollar MARS (M bile Atlantic Range Stations) program, and division ma agement was turned over to the Company's Marketin Manager, J. H. Leutwiler. With Sperry since 1960, M Leutwiler spent 12 years as Vice President of the Missou Research Laboratories, responsible for its sales and ope ations, and was Director of Market Research for the E &

vision of Emerson Electric Company. He received his 5 degree in Engineering from Washington University, Louis, in 1941.

oducts for Industry and the Armed Forces

Product lines at Sperry Microwave fall into two broad tegories. The first includes special-purpose customlored items that are strictly military in application (i.e., ound spectral measurement equipment for the Military ollection Plan for Equipment Spectrum Signatures, part the Department of Defense's Electromagnetic Comtibility Program; automatic checkout equipment for the 58 Hustler aircraft, parametric amplifiers for the Navy's los Radar, etc.). In the second class are components d equipments with a far broader application which erry sells both to commercial and military customers. st sets, microwave components, solid state devices and aterials, radiation monitors, and the Microline product e are just a few of the items being manufactured by erry Microwave for the dual market. Many of these oducts are developed at Sperry's expense and manuctured in relatively large quantities. Competition — th technically and economically — is keen . . . and gineering, production, and marketing departments rk closely together to produce and distribute the best oduct at the lowest price. One example of a successful am effort is the entire Microline operation, with its line almost 200 items.

Advances in microwave technology during and shortly ter World War II created the need both for advanced easurement techniques and for new equipments which uld be used to make the required measurements rapidly d easily. During this early period, Sperry was responble for numerous state of the art advances in measureent techniques and instrumentation (for example, the velopment of a practical barretter, self-balancing watteter bridge concepts crossguide couplers, resonant aveguide cavities). All of these techniques are still in despread use by the industry as a whole.

During the Korean War (despite the fact that Sperry's oneering efforts had put Microline on top), emphasis was nsferred to projects for the Military. The skilled Microe engineers and manufacturing personnel were needed develop and produce test equipment for the Armed rces.

With the formation of the Sperry Microwave Electron- Company in Florida, Microline was given a planned d deliberate 'shot in the arm'. A separate, integrated ganization was set up within the company to handle ery aspect of the Microline operation . . . to develop w items at competitive prices and build up and market well-rounded line of off-the-shelf units. Ed Friebele, anufacturing Manager at Sperry Microwave, put the tire program into action. Paul C. Ely, Jr. heads an thusiastic team of engineers who are responsible for engineering phases of Microline . . . from initial conpt through set up and tooling for manufacture. (Many erry-ites wonder whether Microline laboratory and gineering personnel ever go home!) On the producn line, careful monitoring combined with many highly genius assembly techniques assure that high quality w cost units are turned out on schedule. To complete the integrated Microline operation, the Marketing section has energetic Charles Brown in the driver's seat.

Under the new set up, the entire line of almost 200 instruments — which range from waveguide components through rf power meters and klystron power supplies to microwave receivers — has been redesigned, restyled, and made available as off-the-shelf items. In fact, at the 1961 IRE Show, more than 70 new instruments were introduced. Another innovation has been the quarterly Microline Monitor which provides technical information on new or improved measurement techniques and new product applications.

Plans have been set up to accelerate Microline activities even further in the coming year and additional instruments with new specifications, improved performance, and competitive prices will be made available as stock items.

Solid State Materials and Devices . . . Some of Sperry Microwave's most challenging and rewarding programs are being carried out in its Solid State Materials Laboratory, a combined research lab and materials production facility. Lab scientists work very closely with members of the Solid State Devices Department. Frequently, materials research and studies are directed specifically toward development of a solid state material whose properties will satisfy a new component or system requirement. And, conversely, new component development is often initiated because a new material makes them possible and practical.

Dr. John Pippin, who directs the basic and applied research in materials and microwave circuitry, came to Sperry in 1958 from Harvard University. Robert Duncan, who is responsible for new component development, production, and application, has been with Sperry since 1952.

Creative studies and painstaking experiments are part of the continuous search for advanced materials, superior compositions, and new applications. Company Management budgets a substantial amount of money yearly to support new solid state materials research and component development. Both Mr. Leutwiler and Mr. G. Jaynes, Sperry's Controller, recognize that ample funds are necessary and, based on past experience, that the money will be used to maximum advantage by technically competent, imaginative, and practical leaders and their high level technical staffs . . . and that an alert Marketing Department knows what to do with the finished product.

When Sperry Microwave was established, the men heading each Department were given complete freedom in seeking out and hiring those scientists who, in their opinion, were best qualified in every possible respect for the contemplated work. Each man was literally hand picked.

Having set up such a working environment, Sperry Microwave's management expected to see significant results . . . ranging from major technological breakthroughs through real sales volume.

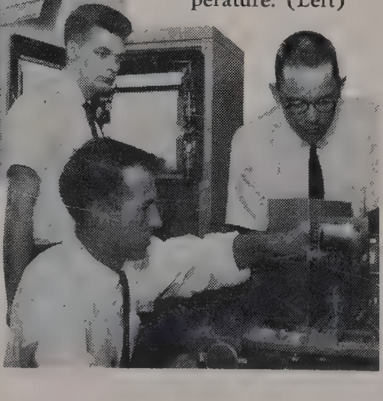
In the Solid State Materials Laboratory, four types of projects are underway at all times: long range studies, programs in which the feasibility of new compositions is being demonstrated, manufacture of solid state materials for use in components and systems, and manufacture of materials for sale on the open market.

Among the programs which still have quite a way to go are those involving research on the properties and application of ferroelectric materials, similar efforts on hexagonal materials, including many planar and uniaxial systems, and single crystal applications in microwave devices. Much further ahead in progress are new limiters using single crystal garnet materials. The feasibility of numerous mixed garnet compositions has already been demonstrated. Using yttrium iron garnet as a base material, Sperry has substituted many different ions into the structure to achieve microwave properties; these hybrid materials are now being used in numerous circulators, duplexers, and isolators. Similarly, of the many different ferrite compositions studied, the most desirable have been incorporated in a wide variety of microwave devices. The Solid State Materials Laboratory is well equipped for preparing the poly- and monocrystalline materials used in all of these devices, and can also supply materials to meet special customer requirements.

These advanced materials. with their consistent composition and characteristics, have made possible a number of Sperry 'firsts' as well as a broad product line of solid state microwave components. These include miniaturized internal magnet coaxial isolators, miniaturized broadband coaxial isolators, strip transmission line (UHF) isolators, high and low power octave bandwidth coaxial and ridge waveguide isolators, miniaturized 3-port Y-junction circulators, and miniaturized high and low power circulators.

Sperry Microwave — like any other company that undertakes R & D programs in new fields — finds it most encouraging when tangible results (technically and economically) are obtained within the estimated time. Apropos here are the programs involving parametric amplifiers and pump sources, including the development of L-, S-, C-, and X-band parametric amplifiers, and a C-band tracking channel parametric amplifier for monopulse radar systems; an ultra low noise parametric amplifier operating at very low temperatures; a solid state microwave pump source and other ultra stable pump circuits.

Drs. John Pippin, research section head, A. L. Stanford, research engineer, and senior engineer Roy Arnold observe transmission response of a ferroelectric-loaded section of coaxial line as a function of temperature. (Left)



Drs. A. L. Stanford, G. R. Rodrique, research engineers, and Roy Arnold adjust a yttrium garnet single crystal preparatory to performing X-ray diffraction experiment.

Based on the results of these and other efforts, Sper Microwave has received several production contracts. O one, Sperry is turning out a sizable quantity of parametr amplifiers to be used in an advanced radar system in co junction with side lobe suppression circuits. Anoth production contract — for complete solid state front en for a modern Navy radar system — includes solid sta duplexers, limiters, circulators, mixers, parametric ampl fiers, and a pump source.

These advanced state-of-the-art devices and syste owe their origin, successful development, and economi productizing to the fine working arrangement betwe the Solid State Materials Laboratory and Devices Depa ment and to Sperry Microwave's encouragement of th study and research programs.

Robert Duncan and his staff also play a big part turning out a full product line of microwave componen some conventional, some highly miniaturized and wi very special characteristics. In a few years they ha made available as stock items such components as dire tional couplers, attenuators, mixers, and cavities in a common transmission lines with frequencies below 20 Mc and as high as 70 Gc. In addition to these off-th shelf items, George Neumann, who directs most of th work in this area, maintains a large inventory of desig and draws upon them to produce components in accor ance with a set of customer's specifications and dime sional outlines or limits. Among the less convention microwave components developed and productized Neumann's group are high power duplexers, isolato water loads, circulators, switches, and harmonic suppre ors in ranges which are being extended to cover t spectrum below 200 Mc through X band.

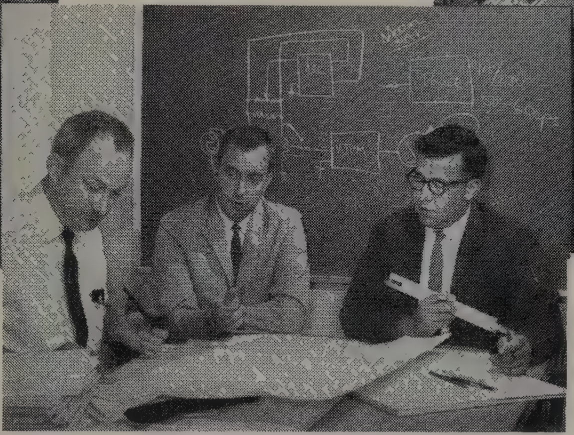
While these 'hardware' items do not have the glamo of many of Sperry's advanced solid state componen they certainly are vital elements in microwave system radars, and test equipments.

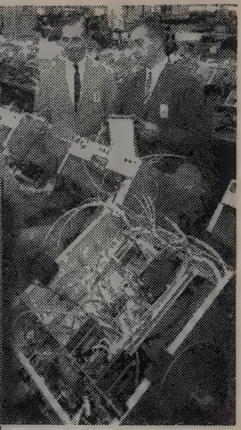
Support Equipment . . . While many of Sperry Mic wave's current programs are in fields that were alm unknown to industry 20 years ago, there are other are in which Sperry's pioneering work began over two de ades ago. In this category are many types of milita test and checkout equipment whose reliability and util have kept Sperry in a position of leadership in this fie Items such as portable combination test sets (for fi echelon checkout of radar and beacon systems) help establish Sperry's reputation for 'firsts' in the test equ ment field. A large number of modern counterparts the original line of 'firsts' are in production today . Two of these instruments (the AN/UPM-32 and t AN/UPM-11A) are being supplied as ground suppo equipment for the F104 NATO program, while su range calibrators and radar test sets as the AN/SPM-4, and -6A are used to support the Navy's Terrier, Tart and Talos programs. Larger units such as radar pe formance analyzers, magnetron and TWT testers, sim lators, and automatic checkout equipment for jet-aircra weapons systems are being delivered to the Air For Navy, Federal Aviation Agency, etc.

Sperry Microwave also has additional programs this field. Under the direction of F. D. Mirabella, o team is hard at work on a program involving advanc techniques and equipment for ground spectral measu ments required for the Electromagnetic Compatibil

Ron Greenwood, senior staff engineer, uses Sperry Microwave Model 61A1 attenuation measuring system for highly accurate signal generator calibration.

Senior staff engineer Doug Wells, Paul Ely, Microline engineering section head, and Ron Greenwood review new Microline product design.





Manufacturing manager E. J. Friebele and Paul Ely check Microline Model 62A1 klystron power supply production line.

nalysis Center, Annapolis, Md. This task is keyed into ne Spectrum Signature Plan of the Department of Dense's Electromagnetic Compatibility Program. Under contract with the Electromagnetic Vulnerability Laboraory of RADC, Sperry Microwave will provide a mobile eld laboratory capable of making all the radiated measrements of rf transmitter and receiver characteristics ccurately and rapidly under field operating conditions. he individual equipments in the laboratory will be of ne most advanced design consistent with the state-of-thert. The end result will be a semi-automatic and selfalibrating system for ground spectral measurements, ith automatic data recording in both analog and digital orm. Another Mirabella team is developing equipment be used at Patrick Air Force Base to check out the erformance of all C- and S-band beacons before they are laced in space vehicles. Still in the planning stage is system to check out these beacons on the launching pad uring countdown.

Sperry Microwave has been certified by the National eronautic and Space Administration under Specification DS-1, which qualifies the company for the highly precise ork required to assure the utmost reliability that is nandatory for all missile tasks.

perry People

Sperry Microwave is actually two things: a building nd people. When the Sperry Rand Corporation charters new division, it defines the areas in which the division ill work. The selection of the site, the architectural esign and layout of the plant, and the capital equipment nat is installed are, within the limits of reality, all lanned to assure as optimum an environment as is possile for the specific types of work to be done. For Sperry and this is, of course, good business and one of the est ways to assure an equitable return on its investment. or Sperry Microwave this made it possible to start off ılly equipped and fully staffed.

Since Sperry Microwave's work ranges from basic research through large scale production . . . of microwave solid state materials and devices, microwave components, test and support equipment, and antennas . . . the building has ample research labs, areas devoted to design and development, model shops, manufacturing and assembly departments, test and quality control facilities, library, and an antenna range adjoining the plant.

While the industrial climate at Sperry Microwave makes it a good place to work, its employees have found Florida's West Coast a good place to live and play after work from the suburbia of Clearwater, through the smalltown placidity of little communities like Largo, Safety Harbor, Dunedin, and Tarpon Springs, to the urban advantages of metropolitan Tampa and St. Petersburg.

Several years ago, the fear existed that working in Florida would isolate technical personnel from important scientific contacts and activities. This has been dispelled by the influx of new industry into the immediate area, by the graduate work offered locally through the University of Florida, by the several new colleges set up in the past year or so, and by the formation of active technical groups such as the Florida West Coast Section of the IRE.

Marketing

Since Sperry Microwave has a diversified product line and much of the output (R & D as well as hardware) goes into the rapidly changing microwave-electronics market . . . the direction of the marketing effort demands a highly flexible and anything-but-static approach. Frank J. Lavelle, Sperry Microwave's Marketing Manager, has set up his department as a combined business-oriented and technically-oriented activity. This combination —an integral part of planning, market analysis, liaison between customer and technical personnel, and actual 'selling' — has enabled Lavelle to direct the overall sales activity into profitable channels.

Marketing analysts, sales (liaison) engineers, contract administrators, as well as promotional planning and advertising people support the marketing organization within the plant. On the outside are the field application personnel and manufacturer's reps. The in-plant marketing organization works very closely with R & D as well as production personnel, and also with Sperry's outside people, to permit flexibility and maneuverability all along the line. While every attempt is made to emphasize business aspects in seeking out and appraising new opportunities fundamental research capabilities are also considered. In fact, one of the functions of the marketing organization is to recommend allocation of company funds for basic and applied research programs conceived by scientific personnel. Lavelle believes that high level scientists are an excellent source of marketing research data in long range forecasting.

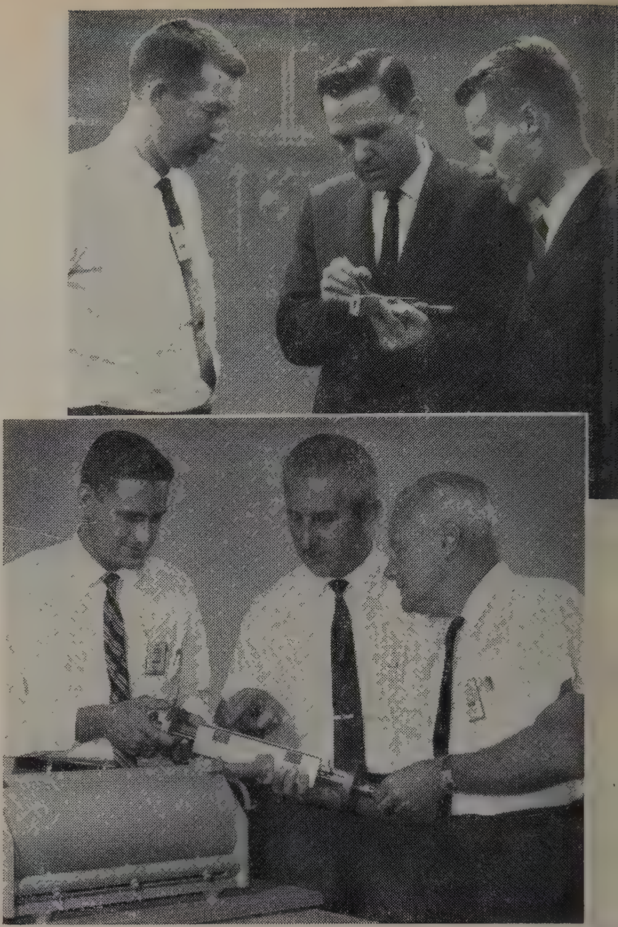
While long range forecasting is highly appropriate in some R & D activities, it can present pitfalls when applied to more timely programs. Sperry's marketing organization has found that the most reliable type of forecast, in view of continuously changing military needs, is obtained by using marketing contacts and know-how as a constant lookout for product possibilities related to its design, development, and production capabilities. This approach has proved valid in that the number of requests for proposal and contracts awarded has borne a sound relation to the forecasts. Such a condition lends credence to future forecasts and gives company personnel a good feeling about 'where they are going.'

Finally, since the business aspect of each bid and contract is significant in building up sales volume and ultimate profits, the Marketing Department works very closely with Engineering and Production personnel — bringing them into sales discussions, acquainting them with the 'facts of life' about costs, deliveries, production levels, customer feedback, and the like. These sessions, both informal and formal, have transferred a good bit of business sense from the 'sellers' to the 'makers' and further solidified the liaison existing between Sperry Microwave's marketing organization and the rest of the company.

Outlook for the Future

Like any other company in the microwave-electronics field, Sperry Microwave has no crystal ball to define its specific research, development, and hardware outputs for the future. Generally speaking, Sperry management foresees continuing activity in the fields in which today's work is being done, with specific programs to be dete mined by technological advances and military requir ments in the coming years.

However, the formula which enabled Sperry Micr wave to achieve considerable technical status up to th point appears to be valid. The Company feels confide that its continued growth will depend upon the sam factors, i.e., providing an optimum working environme and stimulating programs for technically compete personnel.



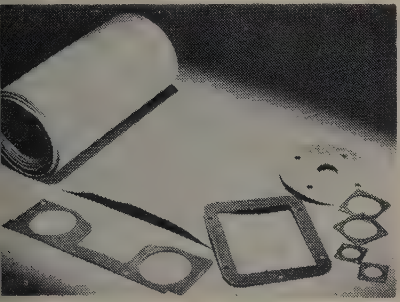
(Top) — Dr. Gordon Harrison, senior staff engineer, B. Duncan, section head, and senior staff engineer E. S. Grimes d cuss structural design characteristics of production prototy non-degenerate parametric amplifier. (Bottom) — L. Whick senior engineer, and section heads George Neumann and L Rehberg inspecting zero db TE_{01} mode circular wavegu variable attenuator (right) and duplexer.

ew Products

(*Continued from page 131*)

UOLASTIC GASKETS AVAILABLE IN PROTOTYPE QUANTITIES

New from Technical Wire Products, ranford, N. J., are dual-purpose RFI ield and Fluid Sealing gaskets supplied prototype quantities to specification. ade of Duolastic (TM), wire screen im- regnated with fluid sealing materials, the skets are extremely thin (0.020 inch ick) and can be cut to order in any riety of complex and intricate shapes, in most any size desired.



First to offer prototype custom cutting rvice, Tecknit will supply gaskets to our drawing or specification in prototype production quantities. A prototype iantity of five to ten pieces can usually supplied for a total cost of $10 to $40, cluding a non-repeating setup charge for ie cutting die. Quotations on both pro- otype and production quantities are avail- ble on request.

Duolastic's aluminum wire screen provides a Radio Frequency Interference total shielding effectiveness of 75 to 100 db, with an insertion loss of 40 to 60 db. The Neoprene or Silicone impregnation provides pressure-tight fluid sealing in the gasketed joint. The gaskets are particularly useful in applications where minimum thickness or intricate shape is required, or where space limitations do not permit RFI and fluid seals in parallel.

Circle Reader Service Card 139

— *m w j* —

ALNICO MAGNET MATERIAL USED IN TRAVELING WAVE TUBES

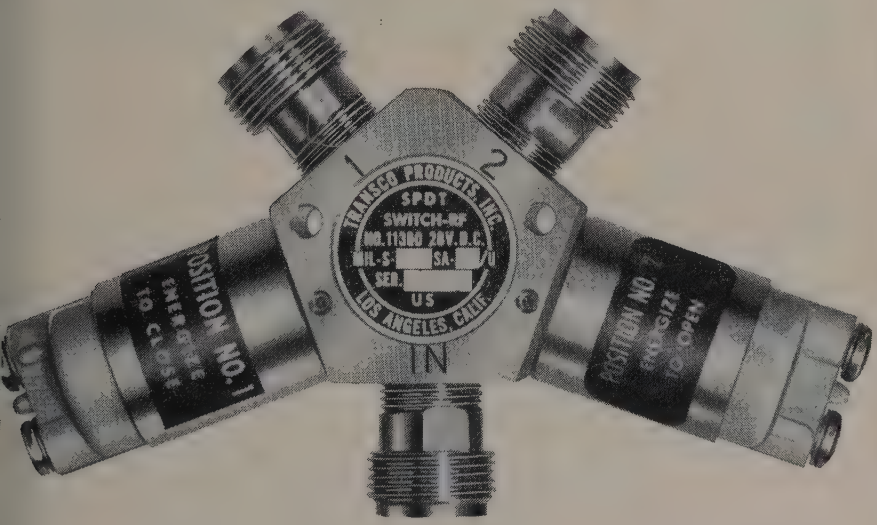
Alnico VIII, a new permanent magnet material with magnetic properties is now being produced by the Indiana Steel Products Division of Indiana General Corp., Valparaiso, Ind., in production quantities.

Indiana Steel engineers report that Alnico VIII has the highest coercive force (Hc) of all the Alnicos, 1400 oersteds. This, combined with a low temperature coefficient, makes it especially well suited for periodic focusing of traveling wave tubes. The new development will help to eliminate operating temperature problems encountered in TWT design.

Circle Reader Service Card 140

— *m w j* —

(*Continued on page 138*)



SWITCH RELIABILITY your problem? Take a look at a Transco coaxial switch qualified for 2,000,000 operations...and reliability isn't the only outstanding feature. This 6 oz. SPDT switch meets MIL Specifications, and is available with 6 RF connector types, AC or DC solenoids and indicator circuits. RF characteristics are excellent...to 11 KMC. Write for complete technical data on "Type Y." Transco Products, Incorporated, 12210 Nebraska Avenue, Los Angeles 25, California. BR 2-5687.

TRANSCO

COAXIAL SWITCHES • WAVEGUIDE SWITCHES • ANTENNAS • MICROWAVE COMPONENTS • VALVES • ACTUATORS

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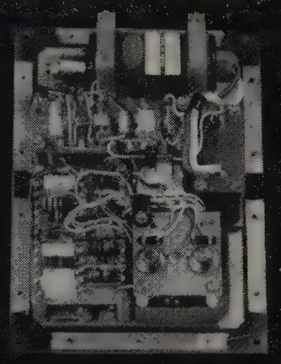
ACF
MICROWAVE
EQUIPMENT



X-BAND TRANSMITTER
TYPE NO. 501

COMPACT DESIGN WITH NO PERFORMANCE PENALTIES. SYSTEM-TESTED FOR OPERATIONAL SPACE VEHICLES. ENGINEERED TO MEET COMPLETE MILITARY MISSILE SPECIFICATIONS.

Frequency Range: 8900 mc to 9400 mc
Wave Guide Power Output: 1,000 Watts, peak
Duty Cycle: 0.002 (maximum)
Pulse Width: 0.45 u seconds ± 0.1 u seconds
Minimum Pulse Spacing: 90 u seconds
Modulation: Pulse
Modulator: Solid State
Input Voltage: 24-30 V DC @ 1 amp.
6 V DC @ 0.45 amp.

May be operated as a free-running pulse transmitter or used with a commutator type telemetry unit capable of providing PPM triggering signals at rates up to 900 bits/sec.

Standard designs modified to meet specific requirements. Complete manufacturing and engineering resources supported by local field service. Full line of components for L, S, C or X-Band Frequencies.

ACF Beacons have qualified for more major satellite and missile programs than any other beacon.

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"Terrier"
on target!

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operational capability
of **BOMARC, HAWK**
and **project SAGE.**
Pitlog equipment is
also used on the
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Cape Canaveral . . . and for
instrumentation of the
T-58 turboshaft engine,
APS-95 ground support
equipment and ASR airport
surveillance radar.

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Aerological and Torque Indicators
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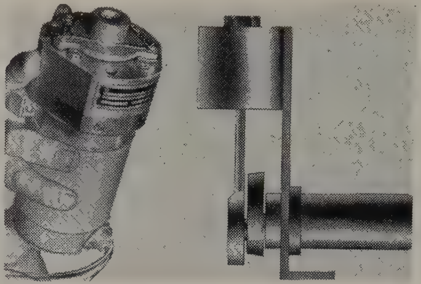
237 Lafayette St., New York 12, N.Y.
Advanced Instrumentation Since 1927

Circle Reader Service Card 81

(*Continued from page 137*)

MINIATURE COMPRESSORS PRODUCE 3 SCFM

Two miniature compressors, producing volumes of 3 SCFM, are announced by Applied Pneumatics, Inc., Kenilworth, N. J.



The oil-free units weigh 3-8 pounds complete with motor, and provide pressures to 100 psig. No carbon rings are used, thereby eliminating carbon deposits in the air system.

Typical uses for the small light weight units include: Cooling electronic devices, radar pressurization, microwave transmission lines, dry box purging, and cable pressurization.

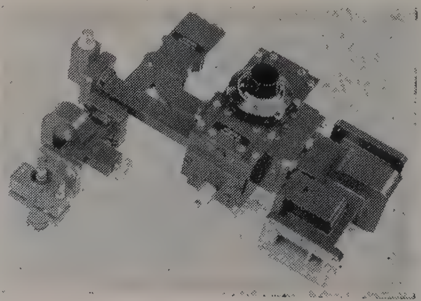
They may also be used for TV transmission lines, aircraft applications, cavities, instrument air drying, and waveguides, in addition to co-axial cable, and duplexers. Three-phase, 400 cycle operation.

Circle Reader Service Card 141

— m w i —

PARAMETRIC AMPLIFIER INCREASES RADAR RANGE 40 PER CENT

Aeronca Manufacturing Corp., Middletown, Ohio, announces a new parametric amplifier (Model PA-C-3). The new unit, which complies with MIL-E-5400, is a reflection, type negative resistance, low noise RF amplifier designed for wide use in radar and communications systems. A model of this amplifier installed on an AN/MPS-16 "C" band radar provided an improvement of 6 db in signal to noise ratio and 40 per cent increases in range. Additional reduction in noise figure can be achieved by use of cryogenic cooling which is available on special order.

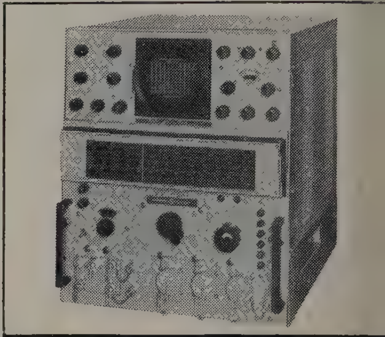


Operating frequency is 5.25 to 6.00 kilomegacycles, tunable over a 10 percent band. Noise figure is 3 db and under most conditions 20 db of gain and 25 megacycle bandwidth can be achieved with pump powers between 40 and 70 Milliwatts.

(*Continued on page 139*)

Circle Reader Service Card 82 ➧

more usable
sensitivity
10 mc to
44,000 mc
IN ONE TUNING HEA



PANORAMIC'S
SPA-4a
SPECTRUM
ANALYZER

Band		RF SENSITIVITY
1.	10 - 420 MC	—100 to —110 db
2.	350 - 1000 MC	— 95 to —105 db
3.	910 - 2200 MC	—100 to —110 db
4.	1980 - 4500 MC	— 90 to —100 db
5.	4.5 - 10.88 KMC	— 90 to —100 db
6.	10.88 - 18.0 KMC	— 85 to —100 db
7.	18.0 - 26.4 KMC	— 70 to — 90 db
8.	26.4 - 44.0 KMC	— 60 to — 85 db

*Measured when signal and noise equal 2X n

Using one tuning head which contains one tr
and two Klystron oscillators, Model SPA-4a of
more exclusive advantages for applications dema
ing extreme sensitivity, stability, versatility, a
racy.

• Exceptionally low distortion • Highly resolved
calibrated analysis • Three precisely calibrated
plitude scales — 40 db log, 20 db linear, 10
power. • Two independent frequency disper
ranges — continuously adjustable —0—70 mc
0—5 mc. Negligible internal frequency modula
permits narrow band analysis of FM problem
Variable I.F. bandwidth from 1 kc to 80 kc
Push-button frequency selector. • Synchroscope
put with 40 db grain. • Accurate measurement
small frequency differences. A self-contained mar
oscillator, modulated by a calibrated external
erator, provides accurate differential marker p
as close as 10 kc.

Tremendous flexibility and many unique adva
of Panoramic's compact SPA-4a make it unsurp
ed for visually analyzing FM, AM and pulsed si
systems; instabilities of oscillators; noise spec
detection of parasitics; studies of harmonic outp
radar systems and other signal sources.

Write, wire or phone today
detailed SPA-4a bulleti

the pioneer
is the leader

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OWens 9-4600 • TWX: MT-V-NY-5229
Cable: Panoramic, Mt. Vernon, N.Y. State

(*Continued from page 138*)

ain-bandwidth product remains constant etween 15 and 27 db of gain.

The high reliability and consistent per-ormance of the PA-C-3 are achieved by elf-bias of the varactor diode which eli-inates the bias supply and corresponding ias-setting controls and results in pro-onged diode life. A wide variety of diode haracteristics can be accommodated with-ut degradation in performance.

The PA-C-3 fits easily within an enve-ope of 0.3 cubic feet and can be installed n a wide variety of mechanical configura-ions with minimum changes to existing quipment. Total weight is eight pounds xcluding pump power supply.

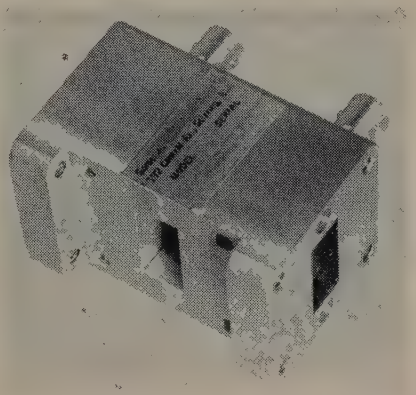
Circle Reader Service Card 142

— *m w j* —

DOUBLE-THROW MICROWAVE SWITCH OFFERED

Somerset Radiation Laboratory, Inc., tirling, N. J., designer and manufacturer f automatic microwave instruments now ffers a double-throw microwave switch or the following applications: Switching nicrowave power up to six (6.0) watts; haring one local oscillator between two r more systems; antenna switching for bstacle-avoidance systems; extremely fast cting radar duplexer.

Features include: Reversed diodes for alanced biasing; available in any combination of waveguide ports and/or Type-N coaxial-line fittings; lightweight and compact.



Specifications are: Peak Microwave Power: 300 watts (0.001 duty cycle); Maximum Average Microwave Power: Six (6) watts; Typical "Open" Channel Attenuation: Twenty (20) db; Typical "Closed" Channel Attenuation: Three (3) db; Frequency Range: 8,200-12,400 Mc; Switching Rate: 0-200 Mc; Temperature Range: —55 to +90 degrees Centigrade. Price of the model X450 is $180.00 each F.O.B. Stirling, N. J. Delivery is from stock.

Circle Reader Service Card 143

— *m w j* —

(*Continued on page 140*)

PRECISION WAVEGUIDE BENDING

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Bends, Twists, Offsets, Coils,
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complete assemblies to your prints.

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ACF
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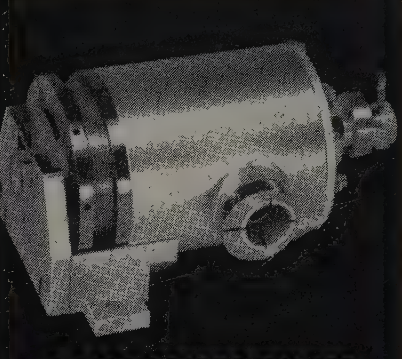

C-BAND TRIODE PULSED
OSCILLATOR MODEL NO. 338

SPECIFICALLY DESIGNED FOR TRANSMITTER SERVICE IN MISSILE AND DRONE TYPE RADAR BEACONS.

Maximum miniaturization with no performance penalties. System-tested for operational space vehicles. Engineered to meet complete military missile specifications.

Frequency Range: 5400 to 5900 mc

Power Output: 1.5 kw min. (200 mc tuning range)
1.0 kw min. (500 mc tuning range)

Stability: ± 3 mc over the most stringent air-borne environmental conditions.

Pulling Factor: Less than ± 2.5 mc for 1.5 VSWR, all phases.

Pushing Factor: Less than 5 kc/peak ma.

Load Variation: Can withstand VSRW's of 6:1 at any arbitrary phase without impairing life expectancy.

Standard designs modified to meet specific requirements. Complete manufacturing and engineering resources supported by local field service. Full line of components for L, S, C or X-Band Frequencies.

ACF Beacons have qualified for more major satellite and missile programs than any other beacon.

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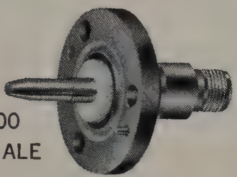
COAXIAL TO COAXIAL TRANSITIONS

IN STOCK

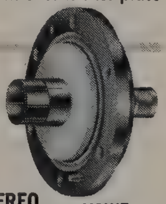
Designed for laboratory or system use, Bogart Series 6000 and 6001 Transitions utilize unique matching techniques to achieve extremely short insertion length. Both series in stock for immediate delivery.



SERIES 6000
TYPE "N" FEMALE

MODEL	COAX	FREQ (KMC/S)	VSWR
NT	3⅛"	DC-0.5 0.5-1.0	1.05 1.10
NY	1⅝"	DC-2.5	1.10
NM	7/8"	DC-4.0	1.15

Flange..................EIA type
Insertion Length..2⁷⁄₆₄, 1⁵¹⁄₆₄, 1¹³⁄₃₂"
Diameter..............5³⁄₁₆, 3½, 2¼"
Finish..................Rhodium over nickel plate



SERIES 6001
TYPE "N" MALE

MODEL	COAX	FREQ (KMC/S)	VSWR
NT	3⅛"	DC-0.5 0.5-1.0	1.05 1.10
NY	1⅝"	DC-2.5	1.10
NM	7/8"	DC-4.0	1.15

Flange..................EIA type
Insertion Length..2⅜, 2³⁄₃₂, 1⁴⁷⁄₆₄"
Diameter..............5³⁄₁₆, 3½, 2¼"
Finish..................Rhodium over nickel plate

Prices	
Type NT	$85
Type NY	$70
Type NM	$50

call or write for complete data

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BOGART

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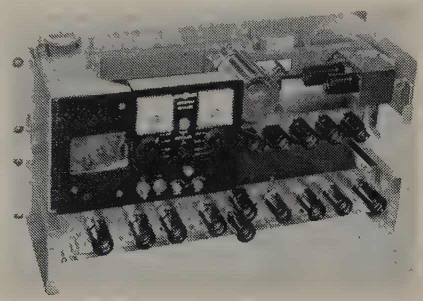
serving the industry since 1942

Circle Reader Service Card 85

(*Continued from page 139*)

ALPHA CORP. OFFERS NEW SERIES OF MICROWAVE TRANSMITTERS, RECEIVERS



The Alpha Corp., a division of Collins Radio Co., Dallas, Texas, has announced a new series of microwave transmitters and receivers operating in the 6-8 kMc and 11-15 kMc frequency ranges. Transmitter power outputs of 100 milliwatt and one watt are available in the 6-8 kMc range and 50 and 500 milliwatts in the 11-15 kMc range.

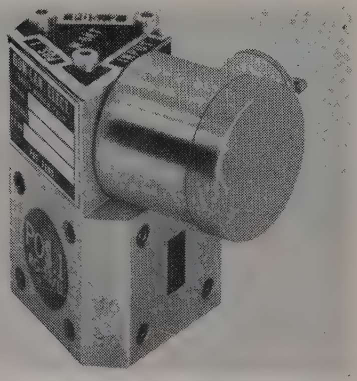
The new systems are especially applicable for wide band data transmission, high density communication systems, and video relaying over long multi-hop systems.

The new receiver has a baseband frequency response of ± .5 db from 50 cps — 8 Mc. Delay equalization in the receiver corrects phase differential in video signals providing color television transmission characteristics. The new transmitter has also been designed with broadband characteristics to accommodate the system requirements.

Circle Reader Service Card 144

— m w j —

DON-LAN ANNOUNCES PRODUCTION OF ITS MICRODELTA WAVEGUIDE SWITCH



Don-Lan Electronics, Inc., Santa Monica, Cal., a subsidiary of Quantatron, Inc., announces that its Microdelta waveguide switch is now in production.

Microdelta switches are offered in 18-26.5 Gc (WR-42) and 26.5-40 Gc (WR-28) models. Features include switching under rf power, seven millisecond operation small size (1.42 1.30 x 1.56 inches) and light weight (tw ounces).

Designed for reliable operation severe environments, these switches a suited for airborne, missile, space a shipboard application.

Standard models are actuated from 28 vdc power supply. Designed f "fail-safe" operation, they return to o put position 1 upon failure or remo of actuator power.

Circle Reader Service Card 145

— m w j —

HIGHLY ISOLATED DC-TO-DC CONVERTER ANNOUNCED

United Electro Dynamics, Inc., Pa dena, Cal., has announced a highly is lated dc-to-dc converter. The unit w convert grounded 28 v dc to fully flo ing and filtered ± 12 v, ± 9 v dc, wi more than 70 per cent efficiency at 1 watts.

Capacitance coupling of the output ground is less than 30 pf. Unbalanc voltage coupling to the secondary co mon is conservatively specified at le than 300 uv p-p per kilohm to ground a nominal frequency of 6.4 kc.

A basic 28 v inverter module suppl square waves to a transformer in the is lator modules. A single inverter dri up to four isolators, depending on t loads.

Circle Reader Service Card 146

— m w j —

MADT TRANSISTORS EXHIBIT LO NOISE CAPABILITIES

Three VHF-UHF MADT transist exhibiting low noise characteristics he tofore unavailable have been introduc by the Lansdale Division of Philco Cor Lansdale, Pa.

The units T2028, T2029, and T2030 a specifically designed for VHF-UHF I amplifiers, mixers and oscillators used military communications equipment, m bile radios and transistorized TV.

Cyrus H. Warshaw, director of ma keting, semiconductor operations, stat that the new MADT transistors, wh operating at frequencies up to 400 M are capable of surpassing the noise pe formance of electron tubes sold at co parable prices.

A method of evaluation which Phil terms as "functional testing" is bei used to assure set to set interchang ability of MADT transistors for co munications equipment.

Circle Reader Service Card 147

— m w j —

OSSED FIELD MICROWAVE DE-
CES, edited by E. Okress, chief editor;
Mourier, J. Feinstein and E. Kettlewell,
tors; and G. R. Feaster, assistant editor.
ademic Press, New York and London,
61; vol. I pp. xxii + 648, $22.00; vol.
pp. xxii + 520, $18.00.

lume I· Principal Elements of Crossed-
ld Devices.

lume II: Principal Types of Crossed-
ld Devices, Analysis of Oscillator Per-
mance, Regional Progress and Trends.

The results of World War II research
d development on crossed-field devices
re summarized in the book "Microwave
agnetrons", edited by G. B. Collins in
48. The present two volumes represent
attempt to perform the same service for
postwar activities in this field. The
k, in 1961, was considerably more diffi-
lt than it had been thirteen years earlier.
ntributions had to be obtained from
thors with widely different interests,
d scattered over the globe. Unfortunate-
the problems raised by this difficulty
painfully apparent throughout the
ok. The level of presentation is uneven,
d there is some lack of continuity. In-
ed one frequently has the feeling that
is reading the proceedings of a topical
nference rather than a coherent treatise.

This is not especially troublesome in the second volume whose subject matter lends itself reasonably well to this form of presentation; and so this volume is by far the more useful of the pair. It begins with a group of chapters that contain descriptions and performance data of the various crossed-field devices that have been developed in the post-war period. This collection, 370 pages long, is a valuable survey of the state of the art. Several sections go beyond reporting the results that have been achieved with the devices, and contain information that should be useful to the engineer in designing further experiments. Some examples are Boot's and Pickering's discussions of long-anode high-power magnetrons, the sections on the "Ultron" and on the coaxial magnetron by Feinstein and Collier, and the reports on millimeter wave work at Columbia University by Bernstein and Kroll. Some of the other sections are less specific and detailed, and occasionally the reader has to distinguish between present achievement and objectives that are yet to be reached; but in general enough material is given to present a fair picture of the field. Part II of volume II, about 120 pages long, contains reports of a number of careful recent measurements of several features of oscillator performance. There

(*Continued on page 142*)

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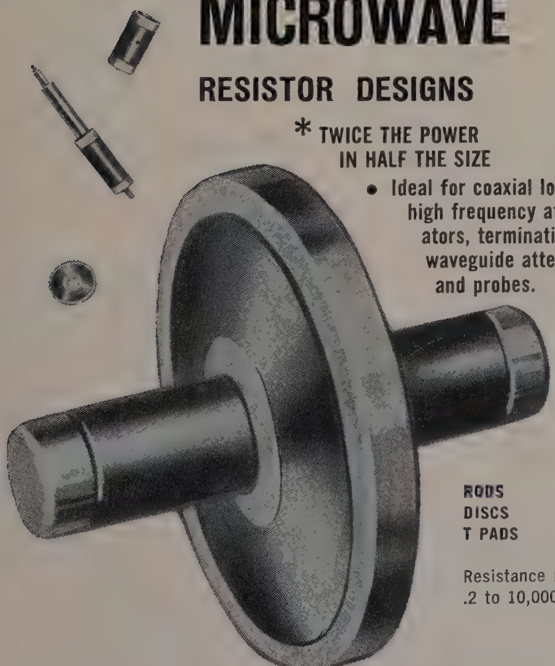

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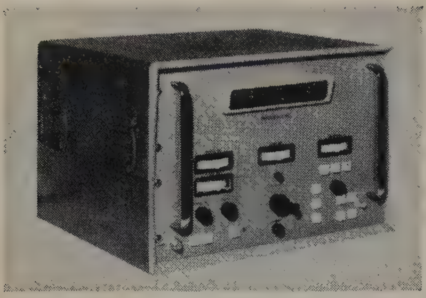
Signal Generator



Model 412 FM Signal Generator, for check out of command receivers operating in the 400-550 mc band, features direct six-place digital readout of frequency. Accuracy to within 1 kc prevails at any setting throughout the frequency range. Continuous coverage is provided by a single tuning control. The unit is ideally suited for both frequency search and for setting to a given frequency, as well as receiver alignment, bandwidth testing, discriminator measurements, sensitivity measurements, filter attenuation measurements.

Power Oscillator

These precision units are designed for laboratory use in the evaluation of antennas, calibration power measuring devices, driving of amplifiers, and other applications where higher power ratings are required. Model 410, shown above, offers a frequency range of 500 to 1050 mc direct reading. Power range is 50 mw to 50 w. The unit measures 8″ x 11½″ x 19″ and weighs 45 pounds. Other models cover ranges from 200-550 mc. All components are conservatively rated and carefully arranged for long life and convenient inspection.

MICRODOT INC.

220 Pasadena Avenue
South Pasadena, California

Circle Reader Service Card 88

Book Review

(*Continued from page 141*)

are chapters on such topics as frequency pushing, "long line" effects, modulation spectrum shape etc. The most serious lack here, and indeed throughout the discussion of performance, is the virtual absence of any discussion of tube life. One would have hoped to find some material on this question which is of such paramount importance in crossed-field devices.

Volume I treats the principles of crossed-field tubes. It contains chapters on circuits, on cathodes and electron guns, on space-charge instabilities, and on small and large amplitude rf interactions. It is here that the disadvantages of multiple authorship are especially serious. Large portions of the theory of crossed-field electron devices are still controversial, experimental work is difficult and many of the experimental results remain ambiguous. The editors have chosen to include expositions of every point of view, and to let the various contributions stand side by side, sometimes in bold contradiction. In the absence of any real agreement among workers in the field this is probably unavoidable; however, the editors could have performed a real service had they provided a critical summary of these conflicting views. A more serious defect of the book must be ascribed to the editors' failure to cut and consolidate the material in order to avoid needless duplication. It is unnecessary to be told on page 496 of a book that would be very long at best that "crossed-field electron interactio may be defined as the exchange of energ between a traveling rf wave and an electron beam which travels at right angle to mutually perpendicular uniform magnetic and electric fields . . . ."; it is irr tating to find identical (except for an in terchange of the x and y axes) pagelon mathematical developments on pages 1 and 166; it is really superfluous to ha the Hull cutoff relation deduced or stat on at least a half dozen separate occasion

Thus the main virtue of this volum lies in the convenience that comes fr assembling a large number of scatter papers in a single source. It cannot recommended as a textbook, but it w serve as a useful reference to the researc worker.

A final criticism must be leveled at th publisher. The incidence of misprint missing or incorrectly numbered references, mislabeled figures, and sentences onl partially translated into English is outsid of reasonable standards of proof-reading The price of these volumes should entitl the purchaser to more careful workmanship.

Reviewed by M. W. Mull
Varian Associate
Palo Alto, Californ

—*mwj*—

FINANCIAL NEWS

NARDA REPORTS 100% INCREASE IN NET EARNINGS

An increase of more than 100 per cent in net earnings on a 16 per cent rise in sales over last year has been reported by the Narda Microwave Corp., Mineola, N. Y., for the period ended June 30.

Fiscal 1961 earnings after taxes were $150,026 or 25 cents a share, compared with $63,811 or 11 cents a share recorded last year, according to William A. Bourke, president.

Sales totaled $2,651,000, as against $2,277,000 for fiscal 1960, while net worth rose from $499,000 last year to $679,000 for the same period this year.

Working capital at year-end 1961 totaled $427,000, compared with $290,000 last year, reflecting in part the establishment in 1960 of a Profit Improvement Committee, said Mr. Bourke.

—*mwj*—

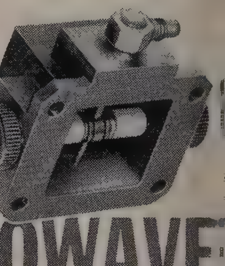
SCIENTIFIC-ATLANTA DECLARES 5% STOCK DIVIDEND

Directors of Scientific-Atlanta, Inc., Atlanta, Ga., have declared a 5 per cent stock dividend payable October 20, 1961 to stockholders of record at the close of business on September 22, 1961.

In action at the annual meeting, stockholders elected the company's Board of Directors composed of James E. Boyd,

(*Continued on page 143*)

"CROSSED FIELD"
BALANCED MIXER



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Financial News

(*Continued from page 142*)

Villiam L. Davenport, Jr., Martin E. Kilatrick, Justus C. Martin, Jr., Walter M. Iitchell, Glen P. Robinson, Jr., and Robrt H. Strange. All of the new directors re presently members of the company's oard.

—*mwj*—

RAYTHEON MAKES UNCONDITIONAL ITS OFFER TO BUY COSSOR SHARES

C. F. Adams, chairman of the oard of Raytheon, Lexington, Mass., has nnounced that the firm is making unconditional its offer to buy the common and preferred shares of A. C. Cossor, Ltd. of London.

Acceptances have been received from tockholders representing more than 87 per cent of the common stock and 94 per ent of the preferred stock.

Raytheon's offer, made in July, was for million common shares outstanding at shillings, 9 pence per share; and for 00,000 6 per cent preferred shares at 20 hillings per share. On this basis, overall price is about $6 million.

Cossor manufactures radio, electrical nd scientific instruments including mobile communications and radar equipment. Its 1960 sales totaled nearly $17 million, lmost 2 per cent of the total electronics ndustry sales in the United Kingdom. It employs about 2500 people.

—*mwj*—

LITTON NOTES 30% SALES INCREASE

Sales of Litton Industries, Beverly Hills, Cal., for the fiscal year ending July 31, totaled approximately $245,000,000, an increase of 30 per cent over the previous year's $187,761,242, Charles B. Thornton, chairman of the board and chief executive officer of the company, stated in a preliminary report to the board of directors recently.

Thornton also reported after-tax earnings for the year at more than $10,000,000 which is 34 per cent greater than the previous year's figure of $7,454,854. Earnings per share, after preferred stock dividends, are estimated at $2.30, Thornton said, up 33 per cent over last year's $1.72.

The preliminary year-end report includes Cole Steel Equipment Co., Inc., which was acquired late in the fiscal year and is accounted for on a pooling-of-interests basis.

Thornton said the directors voted to amend the company's certificate of incorporation to provide for an increase to 17,000,000 shares in the authorized common stock of the company, subject to approval of the stockholders at the annual meeting in November. The present number of authorized shares of common stock is 7,000,000.

—*mwj*—

SANDERS ANNOUNCES 50% STOCK DIVIDEND

Sanders Associates, Inc., Nashua, N. H., has announced that a special 50 per cent stock dividend was voted at a meeting of the board of directors. The stock dividend is in addition to a cash dividend of 4 cents also voted at this meeting.

At the same time the company sharply revised upward its previous estimate of net earnings, climaxing a record fiscal year ending July 30th.

Earnings will be approximately 90 cents per share, according to President Royden C. Sanders, Jr. Previously, the company had stated earnings might go to 80 cents per share. Total net earnings will be approximately $850,000, almost 90 per cent greater than last year's figure of $458,186.

—*mwj*—

FAIRCHILD CAMERA APPLIES FOR NEW YORK STOCK EXCHANGE LISTING

Fairchild Camera and Instrument Corp., Syosset, L. I., N. Y., has filed application for the listing of its common stock on the New York Stock Exchange.

The move followed a previous action on September 19, when Fairchild's Board of Directors called a special meeting of its stockholders to approve an increase in the company's authorized common stock from 2,000,000 to 4,000,000 shares and a 2-for-1 split in the outstanding shares.

Fairchild Camera's common stock is currently traded on the American Stock Exchange, where it has been listed since 1933.

—*mwj*—

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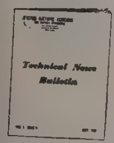

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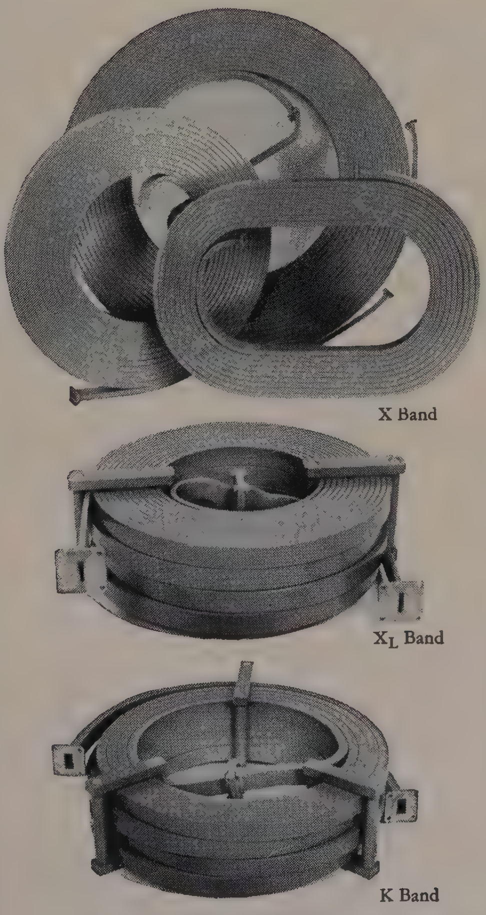

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where accuracy counts

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LETTERS TO THE EDITOR

Ted Saad
Editor-in-chief,
the microwave journal

Dear Ted,

During the past couple of years, I've read a great deal in various publications, including *the microwave journal*, about our vast nationwide engineering accomplishments — engineers, with their tireless amounts of energy, devoting all their time and talents to bettering the field and fattening their pocketbooks. I humbly bow to these erudite, studious "eggheads" who have mastered all the electronic formulas and "state of the art" jumbles previously unsolved by their instructors.

After twelve years in the microwave field I am most confused.

My accomplishments have been few — no patents, no papers submitted for publication, no colossal ideas materialized — not one real, noticeable, worthy contribution to this illustrious field. I have worked steady, and at times hard, installing equipment in the "field", worked up drawings on over 300 microwave components, designed microwave antennae of various configurations, conducted study programs in artificial dielectrics and radomes, designed antennae test ranges, successful in sales, personally wrote four microwave component catalogs (one a 140-page job for one of the largest component manufacturers in the East), was Quality Control co-ordinator for this same company.

Now, Ted, there are "those" who are educated and there are those who aren't. In this day and age "those" fortunate enough to have that BS, BA, MS, EE, PhD, or whatever it is, have it made. They can practically write their own ticket to financial success. I don't happen to be the proud possessor of any of those initials, but I've come close. I have always been a proud person — proud in many respects, proud to be in my chosen field, proud to have worked alongside some of the best in the industry.

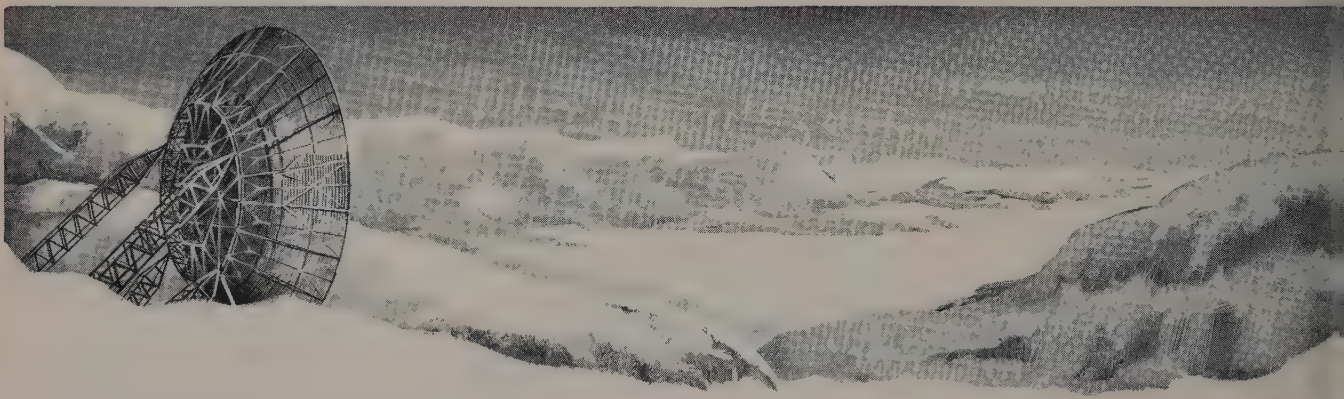
I have been disillusioned. For some reason or other I was of the opinion that, with my meager background, I could get a job anywhere. Not that I would pull down a fat salary, not that I would be given great responsibility or "news-worthy" assignments, not that I would become famous, but just to get ahead making a liveable salary, getting up in the morning, looking forward to going to work as, thank God, I am presently doing by some stroke of luck.

But let's get to the point of my letter. I debated with myself for many days about informing you of my humble but honest complaint which festered up inside me recently during many hot, trying, "door-knocking" days. It is as follows: It is my opinion that the present hiring philosophies and practices of electronic firms — particularly the personnel responsible fo dictating what specific qualities, back ground and "initials" they consider neces sary to supplement their engineerin staffs — *are over-emphasized.* Certainl they are seeking the best qualified peop to fulfill their demands. Sure they wa the most for their dollar, but —— wh about us experienced but formally uned cated people who have 10-15 years good, solid, *practical* experience? The people who were so sorely needed i "those" years of WW II and Korea?

Have you taken a real, honest look some of the help-wanted ads appearing i today's newspapers? Many of them see a person capable of performing a mult tude of duties in U.H.F., microwave solid state, circuits, computers, supervisio capabilities, etc., etc. Besides possessin all these skilled qualities, he should hav a BS or MS, at least 2-3 years experience and should be between the ages of 25-3

Now, Ted, I am not against a forma education — honest, I am not. I trie very hard to make the grade, but unfortu ately did not completely succeed. I'v come far, had many proud moments, bee taught much.

Three months ago I came to Californi looking for a job. I was told by man that I had more experience and technica know-how than necessary to perform th



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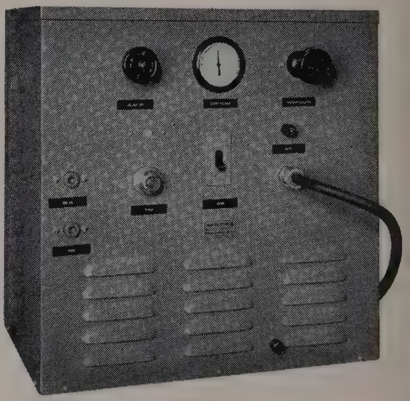
For low dew point operation under ALL climatic conditions, Kahn PRESSURIZER/DEHYDRATORS Models KC-1114 and KC-1207, are specifics. Designed for pressurizing or purging . . . Wave Guides • Radar Systems • Microwave Sub-Assemblies • Solid State Systems • Transmission Lines . . . to dew points below (—) 40°F at flows from 50 scim to 5 scfm. These totally integrated dryer/compressor packages are designed to both MIL and commercial standards and feature . . . Heaterless Regeneration • Lower Installation and Operating Costs • Increased Performance . . . either model can be modified for SF6 atmospheres in wave guide applications requiring higher dielectric properties and enhanced high temperature operation.



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quired duties, but because I lacked the nitials" it was a hopeless case. In other ises I was down-right insulted by a few ersonnel directors, and on two occasions ould not even get to talk to personnel. this what some people call honest hiring olicies?

Much is being accomplished in the di-ection of honest product advertising poli-es, and I say it's about time someone arted to clean up help-wanted ads, starting with company personnel "directors", ho in most cases, are *psychiatrists* in disuise.

I am definitely not against a novice just ut of school with his initials who is quite onfident that the world will come knocking at his door (and it often does). Good ick to him! May he gain much needed *ractical experience.*

How many guys are in my shoes? Can ou take an honest guess? I can't. How nany people do you know that came up ne "hard" way? What about these "selfnade" individuals? Shouldn't they be vorthy of some recognition? Shouldn't hese hiring "experts" recognize their apabilities and hidden talents, their many ears experience, and hard, devoted work? say, Yes! He should be given the opporunity to prove his capabilities.

In many technical editorials today one eads of the poor underpaid PhD, the burens of the engineer, the lack of adequatey staffed colleges.

Can't anyone promote a little *good will* or this type of struggling individual—he uneducated "engineer," given the title because management could not explain his much deserved salary with a technician's title?

Yours truly,
Earl Goss
Advertising Manager
M.C.S. Corp.
Monrovia, California

— *m w j* —

Mr. Ted Saad
Editor-in-chief,
the microwave journal
Dear Mr. Saad,

I thought you might like a comment on your "Service" editorial (*the microwave journal*, July 1961).

Several years ago, imbued with patriotic spirit and experience in weapons application from inner to outer space, and feeling technically competent advice might be appreciated in Washington, I wrote to the then Senator Lyndon Johnson (D. Tex.) in the midst of his hearings on missiles, space, etc., offering my service as a fellow Texan. My first letter was not specifically answered, and the second was mistaken for a job application and answered with a "don't-call-us-we'll-call-you".

After this experience, I decided that Washington wasn't really looking for help, or is so used to patronage requests that it distrusts all motives.

Sincerely,
William E. Cantrell
1741 Weiler Blvd.,
Fort Worth, Texas

— *m w j* —

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Continuing growth of scientific activity at Westinghouse Electronic Tube Division in Elmira, N. Y. has created several outstanding opportunities for experienced MICROWAVE ENGINEERS. Salaries are open, depending on experience and qualifications. A delightful community for work and recreation in the Finger Lakes region of upstate New York.

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Should have experience in one or more of the following areas:

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Outstanding Missile and Space Openings for Electronic/Electrical Engineers

The Boeing Company, system contractor on the Dyna-Soar manned space glider and weapon system integrator on the solid-fuel Minuteman ICBM, has a number of immediate openings for graduate Electronic/Electrical engineers. These positions, available in areas described below, offer challenge and scope, and exceptional opportunities to advance to higher levels of responsibility and income.

RADIO FREQUENCY INTERFERENCE

Assignments in this area include performing electro-interference tests on military equipment; developing familiarization with RFI specification and compliance requirements; evaluating the physics of generation of electro-magnetic interference and methods of reducing susceptibility to both radiated and conducted interference. Requirements: BSEE degree plus minimum of two years of applicable experience.

ELECTRONICS PACKAGING DESIGN

Duties in this area include evaluation, selection, development and documentation of packaging techniques and systems; evaluation, selection, test and qualification of electronic parts and documenting pertinent engineering information; evaluation, development and application of hardware designs for all types of electronic circuits; design, evaluation and qualification of electronic packaging; selection, design and test of production processes; evaluation, selection, test and qualification of special materials.

Salaries are competitively commensurate with education and experience. Boeing provides travel and moving allowances. In Seattle you'll enjoy the advantages of the uncongested, evergreen Pacific Northwest area, famous for mild year-round climate, unexcelled recreational facilities, modern housing, fine schools and outdoor Western living for the whole family.

Send your resume, today, to: Mr. William B. Evans, The Boeing Company, P. O. Box 3707 - MJD, Seattle 24, Washington. The Boeing Company is an equal opportunity employer.

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NEW LITERATURE

SYLVANIA ANNOUNCES TWT BACKWARD-WAVE OSCILLATOR CATALOG

A catalog describing 23 types of travelling-wave tubes and backward-wave oscillators has been published by Sylvania Electric Products Inc., Mountain View, Cal.

Richard A. Stonesifer, product sale manager of Sylvania's Microwave Devic Division, said the catalog lists principa electrical characteristics and major dime sions for PPM and solenoid-focused tra veling-wave tubes operating from 1 Gc 12 Gc. The types listed have rf powe output levels ranging from 5 milliwatts t 1 kilowatt. Temperature-compensated magnetically-shielded PPM traveling-wav tubes for military applications in S-ban are also described.

With six exceptions, the tubes listed i the catalog provide the specified perform ance with full octave frequency coverage All types described can be modified t obtain higher gain and power output a less-than-octave bandwidth.

Two backward-wave oscillators operat ing from 2-4 Gc (100 milliwatts) and 18 26.5 Gc (30 milliwatts) are also described

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— *m w j* —

RADAR BORESIGHTING ABOARD NAVY DESTROYER DESCRIBED IN BULLETIN

Boresighting of radar aboard a U. S Navy destroyer with the use of a 1990-C closed-circuit television camera is described in application bulletin 8-28, released by Kin Tel Division of Coh Electronics, Inc., San Diego, Cal. Specifications and system layout are describe in the bulletin.

Circle Reader Service Card 152

— *m w j* —

FACILITIES AND CAPABILITIES BROCHURE AVAILABLE FROM FAIRCHILD

A 28 page Facilities and Capabilitie brochure is available from the Defens Products Division, Fairchild Camera an Instrument Corp.

The two-color, illustrated brochure contains information on the division's Syosset N. Y., headquarters facility, its Du Mon Military Electronics Department, Clifton N. J., and Curtis Optical Department, Lo Angeles, Cal.

Products, systems and support activitie are described and pictured in detail.. Major sections cover reconnaissance and mapping systems; data processing, display an interpretation systems; communicatio and special radar systems; electronic control and ground support equipment; optics; ordnance products; service engineering; research and development; qualit control, reliability and environmental test and manufacturing.

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— *m w j* —

ARTICLE ON PHASE CHARACTERISTICS AVAILABLE FROM WILTRON CO.

Wiltron Co., Palo Alto, Cal., announces availability of a technical article en- ed "Analysis and Measurement of ase Characteristics in Microwave Sys- ns."

The phase information presented in the icle is valuable to engineers who are ing work with microwave tubes and mponents, including semiconductors, d in physical science research areas such linear accelerators.

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—mwj—

EPORT DISCUSSES MICROWAVE OMMUNICATIONS' COMMERCIAL POSSIBILITIES

An extensive study on the commercial crowave sector, published recently by ;ht graduates of the Harvard Business 1ool, is now available from Micom sociates, New York, N. Y.

The special 198-page report, entitled Iicrowave Communications: Commer- l Possibilities in the 60's", is the re- t of six months' research and measures implications and impact of the FCC ling to open microwave frequencies ove 890 Mcs for private use.

Although the report is directed to the sinessman in general, it should be found be of practical value to systems manu- turers and suppliers alike.

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—mwj—

FIXED PAD ATTENUATOR BROCHURE ISSUED BY APPLIED RESEARCH

Fixed pad attenuators, terminations and impedance transformers (minimum loss pads) are described in a brochure issued by Applied Research, Inc., Port Washington, N. Y.

The brochure includes technical data, outline drawings and prices. Data is given for applications up to 2500 Mc. The new type C units are described.

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—mwj—

BROADBAND BALANCED MIXER DATA TABULATED IN MDL CATALOG

A two-color, four-page catalog, ME-61, containing tabulated electrical and mechanical data on 10 microwave broadband balanced mixers covering EIA waveguide sizes WR28, 42, 62, 75, 90, 137, 187, 284, 430 and 650, is available from Microwave Development Laboratories, Natick, Mass.

In addition to the photo-illustrations shown, a handy order guide facilitates the ordering of broadband balanced mixers for special requirements.

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—mwj—

(*Continued on page 148*)

IMMEDIATE OPENINGS FOR

MICROWAVE ENGINEERS

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New Literature

(*Continued from page 147*)

PGMTT DIGEST STILL AVAILAB

Copies of the 1961 PGMTT Natic Symposium Digest ("Digest of Techn Papers") are still available at $3 per c The Digests may be obtained from F Reggia, Microwave Branch 250, D Washington 25, D. C. Remittance sh be made payable to 1961 IRE-PGM National Symposium.

The Digest covers twenty contrib papers which constituted four sessions cribing millimeter waves, parametric vices, ferrites, and plasmas. Six in papers for the two panel sessions on power microwave techniques and noise microwave amplifiers are summ ized.

"Elementary Consideration of N Performance", a complete paper inclu in the Digest, formed the basis of dis sion for the System and Receiver N Performance Clinic.

— *m w j* —

METEX ELECTRONICS PUBLISH RF DATA FILE

Metex Electronics Corp., Clark, N. has published a technical data file Radio Frequency Designers.

The file contains nine individual sheets covering not only general infor tion and a materials construction gu but also technical data on Electr Weatherstrip, Combo Strip, Compre RF Gaskets, Combination Gaskets, Me astic Gaskets, Knitted Mesh and spe engineered RF Strip.

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— *m w j* —

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Radar Reliability Engineers • Design Review Engineers
Contact Engineers • Field Service Engineers

Los Angeles
(Advanced Inertial Guidance Systems—Airborne Computers)
Transistor Circuit Design Engineers
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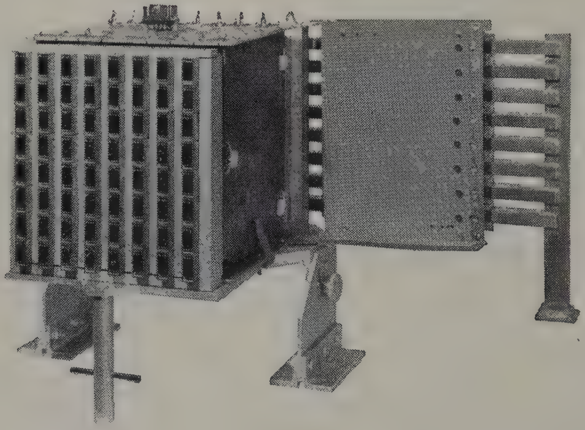

■ Requirements of new and continuing projects concerned with space vehicle communications, navigation, and radar have created new openings for electromagnetic theory specialists as well as antenna engineers. The scientists and engineers of the Research and Development Division of the Hughes Aircraft Company Aerospace Group in Culver City are providing broad scientific and technical leadership to government and company funded programs on advanced airborne and space electronic systems, air to air missiles, ballistic missiles, and satellite and interplanetary communication systems. As part of this team, the Antenna Department is responsible for a diversified program of antenna research and development in the following specific areas:

1. Advanced techniques for space communication and navigation.
2. Information theory and data processing applied to antenna systems.
3. Statistical analysis of scattering propagation.
4. Pattern synthesis from sources on arbitrarily curved surfaces.
5. Aperture control by application of solid state devices.
6. Multi-function aperture and feed capabilities.

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DEVELOPMENT ■ Graduates in E. E. or Physics or extensive experience in lieu of degree. ■ Minimum of three years of professional experience in monopulse and conical lobing antennas in reflector and array configurations, electronically scanned arrays, inflatable and erectable antennas, shaped beam arrays from curved surfaces and signal processing antenna systems.

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PROJECT TOMORROW...

The scientists and engineers at Amherst Laboratories are currently engaged in communications projects which are making vital contributions to our nation's defense efforts. The basic objective of this facility is the advancement of the state-of-the-art of communications and instrumentation systems, with emphasis on the role that microwave and millimeter wave technology will play in that advancement. Coupled with these on-going specific projects, is a freedom of investigation that allows no past premise to go unchallenged, allows no new avenues of inquiry to go unexplored. Together, they form what we like to call "Project Tomorrow"... a total dedication to the advancement of the science of communications.

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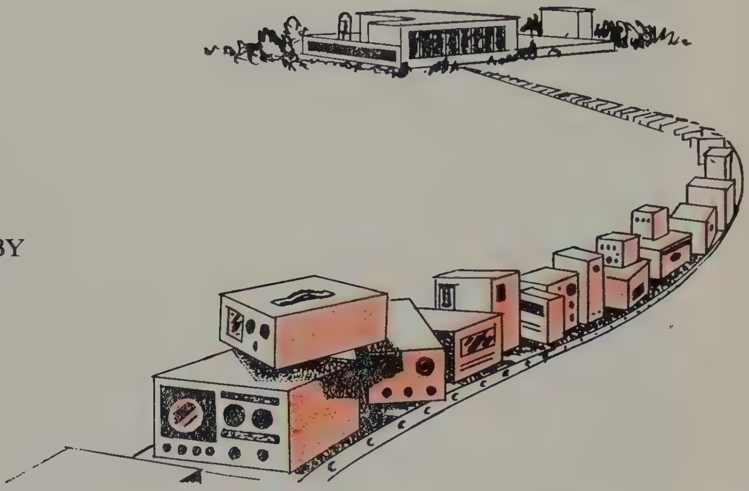
RELIABILITY— FACT OR FICTION?

By M. H. KEBBY



We hear many comments these days on the subject of reliability — comments provoked by the occasional failure of vast machines due to shortcomings of some piece of electronic equipment. What's happening? Are these justified? Or are we misled because so much more electronic gear is being used? Surely it's not that components are becoming less reliable nor design engineers more fearless. In this technological era, we are finding that it's possible to accomplish more and more through electronic means; and, as a result, our systems are becoming exceedingly complex. And failure of any small part of the system may disable the entire equipment. The over-all specifications of the system are important and, to some degree, provide an indication of its reliability. But far more important are the engineering and production considerations which are built into the system. We offer here some thoughts on this subject and some opinions on methods that the equipment manufacturer may use to produce systems of the highest quality.

Obviously, careful planning of the system is the first essential. One must consider first the many different arrangements under which the equipment may be installed, and insure that the expected degree of reliability may be achieved in all cases. Accept the premise that the equipment cannot be practically designed so that it will operate continuously without interruption, and plan the equipment so that the effects of any component failure are minimized.

A vital communication circuit must be equipped with some amount of redundancy — or protection, or standby, if you will. If it is a radio circuit, some action must be taken to protect against propagation anomalies. Or a wire circuit must be protected against damage from the weather, the farmer, the fisherman, etc. Regardless of the medium between terminals, make certain that provision is made for substituting spare equipment automatically, so far as possible, in the event of equipment failure.

Thorough consideration must be given to the metho used to inform manned control centers of the status o all equipment within their jurisdiction. Furthermore these centers must be equipped with means for transfe ring systems and performing various other operations a unattended stations. But the control system must b "fail-safe" and it must not decrease the reliability of th basic communication circuit. Any failure in the contro equipment should switch the circuit into a "normal condition without interrupting service.

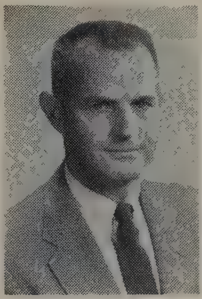
The design of the system should allow for rapid testin of the condition of all critical circuits while in operatio and for quick diagnosis of trouble when such occur Full use should be made of plug-in components and uni to effect rapid restoration of service.

Again obviously, the environmental conditions — a of them — under which the equipment will be expecte to operate should be given careful consideration. Th may sound like belaboring the obvious, but it is surpri ing how many developments are not carried t completion in this respect, either through inadvertenc or deliberate choice. Further, however, not only mu it be capable of providing the specified performance a temperature extremes, but sustained operation under suc conditions should not cause component deterioratio This is a particularly serious problem, of course, at hig temperatures, where chemical reactions affect the life c components.

Up to this point we've discussed some of the practic and considerations involved in the design of the over-a system to provide maximum reliability. Here now a some points which should be kept in mind by the desig engineer.

First, a basic decision: should tubes or transistors c both be used? Let's not blindly say that we'll use tran istors simply because they have no filament to burn ou Remember that the submarine repeaters in the ne

M. H. KEBBY is presently in charge of a new micro-wave system project at Lenkurt Electric Co., Inc., San Carlos, Cal. As manager of the project he is directing the development, initial production, and applications engineering work on this new equipment, which will be used by telephone companies, railroads, other utilities, and government agencies using commercial systems.



Joining Lenkurt in 1951 as a filter design engineer, he was promoted to senior project engineer in 1952, and subsequently has been manager of radio and carrier development departments. In 1957 he was named product development manager, in 1959 was appointed chief engineer of Commercial Products, and assumed his present position in December 1960.

His previous experience also includes electronic development during six years of active duty as a Naval Reserve officer and three years in development work with the Mackay Radio and Telegraph Co. He holds a BSEE degree from Stanford University.

nsoceanic cables were designed to provide the ultimate -reliability. And they use vacuum tubes However, 're quite confident that circuits *can* be designed and nsistors *can* be manufactured that will provide an exemely high degree of reliability. Technology in the id-state field is certainly advancing rapidly, and it is ite a temptation for the equipment manufacturer to sign right up to the state-of-the-art for competitive isons. This is good — but let's not push things so st that reliability suffers.

The "know-how" and capability to design an all solidte microwave system is with us now. But such a sysm would require the use of many more active elements an one using thermionic means for rf power generation. ne reliability of each individual active element in the lid-state system *may* be greater than that in the thermiic system; however, the increased number of componts raises doubts that the entire solid-state system ovides greater reliability. Of course, as manufacturing d design techniques are refined, this situation is rapidly proving.

The circuit designer may make an important contribuon in this field if he will restrict the number of *fferent types* of components used in his circuits. Standdization is one of the principal attributes of quality. It kes a good engineer to get the best and the most from ch element. It's obvious that a reduction in the variety components requested of the manufacturers will allow em to concentrate their engineering and production now-how across a narrower field and so improve reliality. There is no doubt that they are desirous of proucing as perfect a product as they can — and we can a long way toward helping them if we use their gh-volume items.

Important by-products of component standardization e lower maintenance cost realized through a reduction the variety of spare parts stocked by the customer, and course lower manufacturing cost.

For many years the electronic equipment used in the lephone plant was designed around only two different pes of vacuum tubes: a dual-triode and a pentode. ome very ingenious circuits were designed by equally genious engineers who struggled and cursed at the task efore them — but they did succeed. Their job would ave been far easier if they had had a choice of using her types from among the hundreds available.

A most significant step toward greater reliability may realized if we are guided by this sound precept: "Keep simple." This, too, seems like an obvious statement; owever, a critical examination of many present-day deces will reveal the existence of some excessive componnts — not intentional, of course, but a result of the esire on the part of the design engineers to meet specications. Since most designs are under pressure of time, e overly complex circuit can be a natural result. Let's y to schedule a second look at new designs. Not only ill reliability be improved, but cost will be decreased. ere's an area where many concepts of "value engineerg" pay off. Let's also think about the maintenance chnician and remember that the simpler the circuit, the sier it will be for him to understand it, recognize the tal spots, and keep it in operation.

Let's not try to squeeze that last drop of performance t of the components either. Try to remember that initably someone will install the equipment and expect it to operate under adverse conditions. How long would that new car last if you drove it continuously with the accelerator down to the floor-board?

The mechanical packaging of the equipment can have a tremendous effect upon its reliability. The problem of heat removal is one of terrific importance and yet, it is frequently little considered. Certainly it's true that the solid-state devices dissipate considerably less heat than their thermionic counterparts — but on the other hand, they are still far more sensitive to the higher temperatures.

Component accessibility is a subject deserving more attention. Bookcase-style construction with plug-in cards has been a big step in the right direction; however, it has, at the same time, made it more difficult to conduct "in-service" tests and measurements.

The mechanical engineer's job will be made a lot easier, and he will perform it more effectively, if he participates early in the development cycle. So often, the circuit engineer turns over a schematic and a batch of components to the mechanical designer with the admonition that it must work and fit into a given size can or on a particular card. Let's encourage the mechanical and electrical engineers to work hand-in-hand and side-by-side *throughout* the development period.

The importance of a strong and effective material evaluation group cannot be over-emphasized. Rarely will the component manufacturer produce an item meeting all of our requirements. There will always be limitations, and one of the best ways of determining the extent of these limitations is through a competent analysis of each new component by an independent engineering group.

The evaluation function ties in very nicely with a components standardization program. We need components accepted, tested, and *available* for new designs — since the design engineer will not have time to allow for a proper evaluation after he is forced to make a last-minute design change. This means, then, that the material evaluators cannot afford to wait until the designers knock on their door and ask if a new gadget will do the job. They've got to anticipate his needs and stay ahead of him; more is needed than just staying even with the state-of-the-art.

On the manufacturing floor, we're all pretty conscientious about "building" in quality rather than "inspecting" it in. The first consideration, however, is "designing" it in. All too frequently, the first time a quality control engineer is confronted with a new piece of equipment is when it goes into production. He sees many things that should be changed to improve quality and reliability. Look at what he's up against, though, if he wants to make a change at that moment. Chances are that the product is behind schedule, the customers are complaining about late delivery, and Marketing is letting everyone know that shipment must be made promptly.

Let's think about quality in design; assign a quality control engineer to the development group early in the project and give him a chance to make critical evaluations continuously throughout the evolution of the new product at a time when changes can be best handled. Let him review the design margins, the types of components, the packaging, and the test specifications.

While we're designing quality into the new product, let's at the same time design in more producibility. Here again, if we can bring our production engineering forces to bear on the design efforts at an early stage, we stand the best chance of coming up with a product that may be reasonably manufactured. And certainly, the more producible the product, the better the quality.

What else will help us build quality into the product? Perhaps one of the best ways is to instill an atmosphere among the production workers that is conducive to such a desire. We all want to do a good job, and we're proud when we can do so. A pleasant working environment, good supervision, and proper training are all vital to the production of quality equipment. Make the workers feel that they're part of the team, with perhaps some competition between various lines. And keep them informed an tell them how they're doing. Quality control can play an i portant part here through the continuing feedback of info mation concerning reject rates, inspection analysis, etc. Th greater the responsibility for quality that can be place in the hands of production, the more reliable the produc

It goes without saying that a good solid quality contr organization is a must. Not only should it conduct sam ple testing, both in-line and final, but it should also mak periodic audits of stock and inventory. We should al expect that it would provide an incoming inspection fun tion through which all materials would pass prior to a ceptance. An important adjunct to this is th maintenance of a vendor-rating file wherein an up-to-da quality record of each supplier is kept.

Recapitulation

The shipment and installation of a reliable and t quality system can be possible only through the combin efforts of *all* people in a well coordinated planning, d sign, and manufacturing organization. The basic syste must be carefully planned in such a way that it is capab of being installed and operated in a manner which w yield the required degree of reliability, and not just und a narrow range of optimum conditions. It must b designed with well tested components having adequa margin for deterioration under extreme environment conditions and packaged to allow convenient maintenan and repair. It must be manufactured under a quali spirit on the part of all involved, and in a pleasant atm sphere.

Most important, perhaps, is such communication b tween all groups involved that each person will feel personal responsibility to maintain the highest standar possible. The result, then, would make reliability fa rather than fiction, and a product representative of th philosophy of quality on which his company is based.

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25	26	27	28	29	30	31	32	121	122	123	124	125	126	127	128
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41	42	43	44	45	46	47	48	137	138	139	140	141	142	143	144
49	50	51	52	53	54	55	56	145	146	147	148	149	150	151	152
57	58	59	60	61	62	63	64	153	154	155	156	157	158	159	160
65	66	67	68	69	70	71	72	161	162	163	164	165	166	167	168
73	74	75	76	77	78	79	80	169	170	171	172	784	785	786	787
81	82	83	84	85	86	87	88	788	789	790	791	792	793	794	795
89	90	91	92	93	94	95	96								

COVERS
- ☐ FXR
- ☐ Varian
- ☐ Raytheon

INSERT
- ☐ PRD

Use These READER SERVICE CARDS For Requesting More Information on *Products Advertised*

READER SERVICE CARD — Nov., 1961

PLEASE USE BEFORE
JAN. 15, 1962

NAME ________________ TITLE ________________

COMPANY ________________

COMPANY ADDRESS ________________
City Zone State

For More Information, Circle Number Coded to Product that Interests You.

1	2	3	4	5	6	7	8	97	98	99	100	101	102	103	104
9	10	11	12	13	14	15	16	105	106	107	108	109	110	111	112
17	18	19	20	21	22	23	24	113	114	115	116	117	118	119	120
25	26	27	28	29	30	31	32	121	122	123	124	125	126	127	128
33	34	35	36	37	38	39	40	129	130	131	132	133	134	135	136
41	42	43	44	45	46	47	48	137	138	139	140	141	142	143	144
49	50	51	52	53	54	55	56	145	146	147	148	149	150	151	152
57	58	59	60	61	62	63	64	153	154	155	156	157	158	159	160
65	66	67	68	69	70	71	72	161	162	163	164	165	166	167	168
73	74	75	76	77	78	79	80	169	170	171	172	784	785	786	787
81	82	83	84	85	86	87	88	788	789	790	791	792	793	794	795
89	90	91	92	93	94	95	96								

COVERS
- ☐ FXR
- ☐ Varian
- ☐ Raytheon

INSERT
- ☐ PRD

lete this section **ONLY** if you are **PRINCIPALLY** engaged in **COMPONENTS** 0-29

65 ☐ ANTENNAS
1-65 ☐ Large 3-65 ☐ Small (under 10′)
5-65 ☐ Communication 9-65 ☐ Detection
7-65 ☐ Tracking 0-66 ☐ Tropo Scatter
1-66 ☐ Airborne
3-66 ☐ Other ______________
type

67 ☐ TEST EQUIPMENT ______________
type

67 ☐ TUBES
9-67 ☐ Planar 9-68 ☐ Gaseous discharge
0-68 ☐ Passive devices 9-69 ☐ Duplexers
7-68 ☐ Storage 7-69 ☐ Crossfield
1-68 ☐ Klystron 1-69 ☐ BWO
3-68 ☐ High power 3-69 ☐ TWT
5-68 ☐ Low power 9-83 ☐ High power
9-84 ☐ Low power
9-81 ☐ High or 9-82 ☐ low power
9-81 ☐ High or 9-82 ☐ low power
5-69 ☐ Other ______________
type

70 ☐ SOLID STATE
3-70 ☐ Amplifiers 9-70 ☐ Thermoelectric
5-70 ☐ Transistors 7-71 ☐ Masers
7-70 ☐ Paramagnetic 9-71 ☐ Diodes

0-72 ☐ Ferrimagnetics 3-72 ☐ Crystals
1-72 ☐ Parametrics 5-72 ☐ Infrared
0-71 ☐ Ferrites ______________
type
7-72 ☐ Other ______________
type

3-73 ☐ TRANSMISSION LINES
7-73 ☐ Coaxial
9-73 ☐ Waveguide

0-74 ☐ SMALL COMPONENTS
1-74 ☐ Bolometers 3-75 ☐ Filters
3-74 ☐ Holders & Mounts 5-75 ☐ Attenuators
5-74 ☐ Horns 7-75 ☐ Limiters
7-74 ☐ Hybrid Junctions 9-75 ☐ Diplexers
1-75 ☐ Switches 0-76 ☐ Terminations
5-76 ☐ Coaxial
7-76 ☐ Waveguide
1-76 ☐ Other ______________
type

9-76 ☐ WAVEGUIDES
0-77 ☐ Rigid
1-77 ☐ Flexible
5-73 ☐ Transitions
3-77 ☐ Windows

0-78 ☐ MILLIMETER ______________
type

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54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 86 87 88 89 90

omplete this section **ONLY** if you are **PRINCIPALLY** engaged in any activities sted below. 0-33

☐ Please check here if you are engaged in Research and Development work and if your activities encompass general phases of "the microwave journal".

-79 ☐ MAGNETICS ______________
type

-79 ☐ CRYOGENICS ______________
type

-86 ☐ PLASTICS
5-86 ☐ Radomes 0-87 ☐ Dielectrics
7-86 ☐ Insulation 1-87 ☐ Absorbers
9-86 ☐ Packaging
3-87 ☐ Other ______________
type

-87 ☐ MATERIALS
7-87 ☐ Garnets
9-87 ☐ Germanium
3-88 ☐ Galium arsenide
5-88 ☐ Inter Metal. Comp.

1-88 ☐ Ferrites 7-88 ☐ Rubies
9-80 ☐ Silicon
9-88 ☐ Other ______________

0-89 ☐ PLASMA ______________
Field

5-89 ☐ SPECTROSCOPY

7-89 ☐ OPTICS

9-89 ☐ NUCLEAR
0-90 ☐ Linear Accelerator
1-90 ☐ Cyclotron
5-90 ☐ Atomic beams
3-90 ☐ Other ______________
type

9-90 ☐ FERROELECTRICS

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Address to which you wish the journal sent — home address preferable.

____

____

If you have changed your address, place your previous address below.

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Please check the areas in which you are PRINCIPALLY engaged.

☐ DEVELOPMENT
☐ DESIGN
☐ RESEARCH
☐ MANAGEMENT
☐ APPLICATIONS
☐ PURCHASING
☐ PRODUCTION
☐ EDUCATION
☐ SALES
☐ MFG. REPRESENTATIV
☐ OTHER

If you are working for Government, please specify ☐ Civil or ☐ Military Agency.

FOLD

Complete this section ONLY if you are PRINCIPALLY engaged in SYSTEMS. 0-25

0-26 ☐ RADAR ______ type
1-27 ☐ MISSILES
  3-28 ☐ Tracking 5-28 ☐ Guidance
  9-28 ☐ Other
3-30 ☐ GROUND SUPPORT ______ type
7-28 ☐ AIRBORNE ______ type
0-31 ☐ ASW ______ type
7-31 ☐ TELEMETERING ______ type
9-32 ☐ DATA PROCESSING ______ type
5-34 ☐ RADIO ASTRONOMY ______ type
  1-32 ☐ Radiometry 7-34 ☐ Other
1-41 ☐ COUNTERMEASURES ______ type
3-41 ☐ POINT TO POINT RELAY LINKS
  5-42 ☐ Commercial MW Relay User
    ☐ Industry served ______
  9-42 ☐ Relay equipment manufacture

5-41 ☐ DETECTION SYSTEMS
  7-41 ☐ Infrared
  9-41 ☐ Other ______ type
1-43 ☐ SONAR
  3-43 ☐ Ultrasonics
  5-43 ☐ Other ______ type
1-44 ☐ COMMUNICATIONS
  3-44 ☐ UHF, VHF
  5-44 ☐ Space Communications
  7-44 ☐ SSB Trans.
  9-44 ☐ Radio, Television
  7-45 ☐ Mobile
  9-45 ☐ Data Transmission
  3-45 ☐ Other ______ type
0-63 ☐ SUBSYSTEMS
  1-63 ☐ Power supplies
  1-45 ☐ Transmitters
  0-45 ☐ Receivers
  9-63 ☐ Circuits
  7-63 ☐ Other ______ type

FOLD

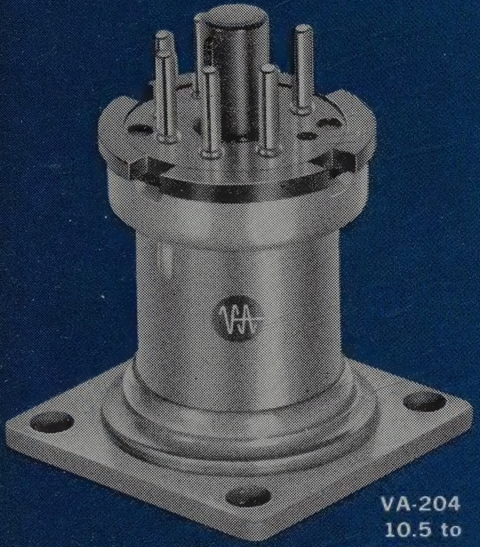
the microwave journal

NEW SUBSCRIPTION CARD

DON'T RELY ON BORROWING SOMEONE ELSE'S "MICROWAVE JOURNAL." FILL OUT THIS NEW SUBSCRIPTION CARD *TODAY!*

PUBLIC SERVICE BAND REFLEX KLYSTRON

LOW COST, HIGH RELIABILITY



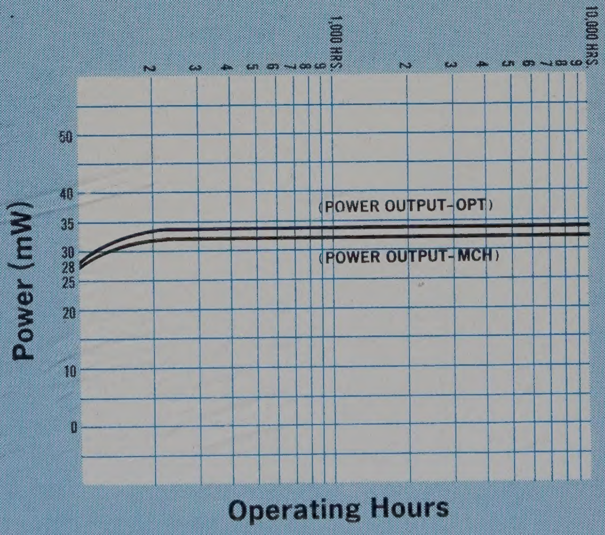
VA-204
10.5 to
10.55 Gc

APPLICATIONS:

- POLICE RADAR
- TRAFFIC CONTROL RADAR
- METEOROLOGICAL ROCKETS
- SECURITY RADAR
- RAILROAD TRAFFIC CONTROL

Varian Associates introduces the new VA-204 reflex oscillator klystron to fulfill an industry need — low cost tubes with traditional Varian reliability.

The fixed-frequency VA-204 satisfies design requirements for nearly all types of low-power doppler radar systems intended for operation in public service radio location bands. Features include long life, rugged construction and simplicity of installation. Ideal for long periods of unattended operation. Beam voltage, 300 Vdc; beam current, 28 mAdc. Waveguide output, single plug power connection. For more information, write Tube Division.



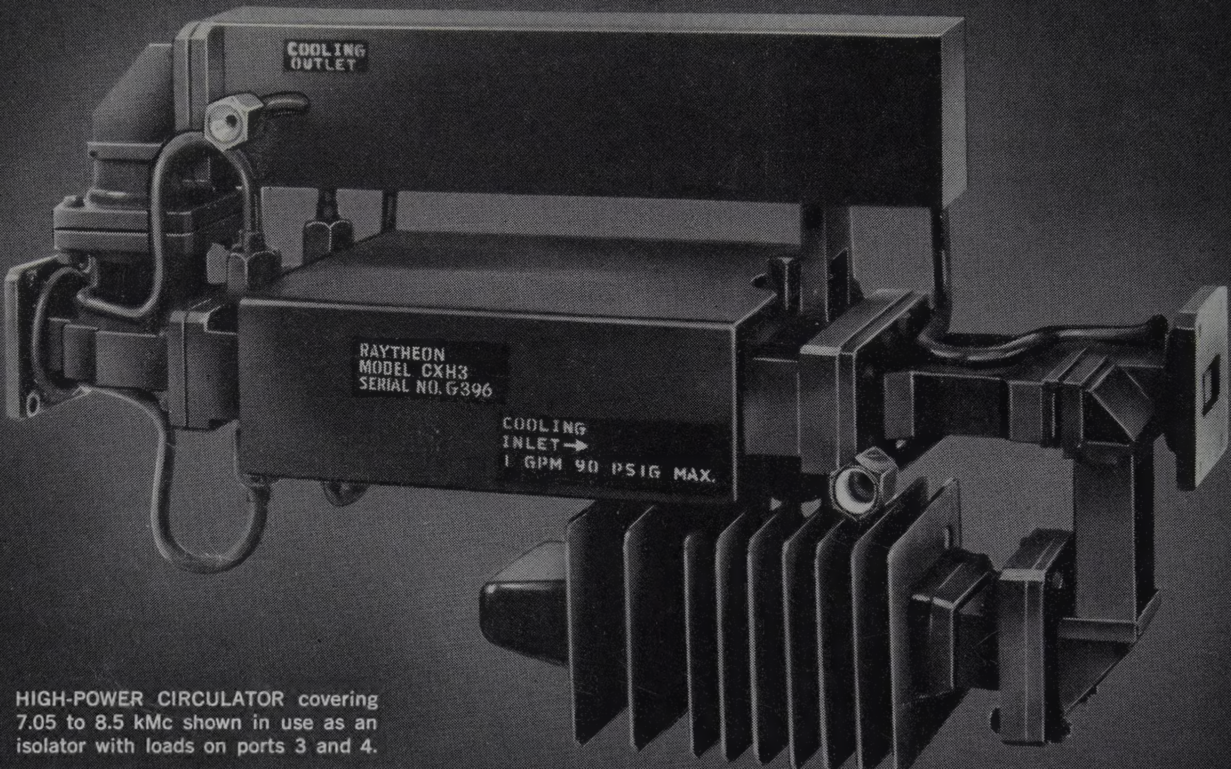
VARIAN associates

PALO ALTO 34, CALIFORNIA

Subsidiaries:

BOMAC LABORATORIES, INC.
VARIAN ASSOCITES OF CANADA, LTD.
S-F-D LABORATORIES, INC.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A. G. (SWITZERLAND)

RECENT RAYTHEON DEVELOPMENTS
IN MICROWAVE FERRITE DEVICES



HIGH-POWER CIRCULATOR covering 7.05 to 8.5 kMc shown in use as an isolator with loads on ports 3 and 4.

X-band circulators take 20 kW CW to match state of the art in tubes

New unit tested at 20 kW continuous power; can be used as isolator or duplexer

This high-power CXH3 circulator provides greater than 20 db of isolation over the 7.05 to 8.5 kMc band with a maximum insertion loss of less than 0.3 db. The CXH3—developed under U. S. Army Signal Corps contract number DA-36-039-SC-85372—is typical of circulators Raytheon can supply for any X-band segment at power levels up to 25 kilowatts average and 2 megawatts peak.

Write for technical details on this and other significant developments in high-power microwave ferrite devices to Special Microwave Devices Operation, Raytheon Company, Waltham Industrial Park, Waltham 54, Massachusetts.

TYPICAL SPECIFICATIONS
MODEL CXH3 CIRCULATOR

Frequency Range	7.05-8.5 kMc
Power (CW)	20kW
Isolation	20 db min.
Insertion loss	0.3 db max.
VSWR	1.15 max.
Length	14.5 inches
Flanges	UG 51/U
Waveguide	RG 51/U
Weight: Incl. loads	19 lbs.
Excl. loads	12.5 lbs.
Cooling	1 gpm @ 90 psi max.
Recommended Pressurization	10-15 psig nitrogen or dry air

RAYTHEON

RAYTHEON COMPANY

SPECIAL MICROWAVE DEVICES OPERATION